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Errata: In the issue of October, 1975, the following corrections are required.

Page 18: In the author's identification, bottom of page, the initials ICRISAT stand for International Crop Research Institute for the Semi-Arid Tropics (not International Center for Research in the Semi-Arid Tropics).

Page 22: In the last paragraph, line 4, it was stated that "some 20 factories have been selling pellets containing rhizobia . . . " in Australia. In fact, the making of rhizobia pellets has now been concentrated from previously dispersed locations into only two laboratories, although numerous distribution facilities remain.

(Unless otherwise indicated
currency is expressed in U. S. dollars.)

URBAN FINANCE
MARIA

AERIAL VIEW OF SAO PAULO, BRAZIL
(PHOTO: BRAZIL INFORMATION BUREAU)

Financing Cities in Developing Countries

Roger S. Smith

[This article surveys finances of a large sample of cities in developing countries, including for comparison three in industrial countries, and presents the distribution of their expenditures by function and the revenues derived from different types of taxes and other sources. It also discusses a number of general policy issues and suggests directions for finding revenue sources.]

The Problem and Its Causes

The continued poverty of cities is troublesome but not surprising. Cities are generally allocated revenue sources by higher levels of government, so that local governments normally depend on the generousity of their too often poverty-stricken parents. But higher levels of government may not relinquish for local use those revenue sources which they themselves value, or consider potentially valuable, unless forced to do so by crises at lower government levels.

In many cities the need for public services has simply outstripped the ability to pay for them. Stagnant agricultural sectors have contributed to the flow of individuals to the cities, and rapid population growth made possible by medical advances has also contributed to high urban growth rates. The most important factor contributing to urban growth may well be the increased opportunity, productivity, and higher incomes that are drawing people to the cities. This might suggest that the urban centers should be able to

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pay for the services that they ought to provide. If they cannot, who can? Such a question oversimplifies the problem. One reason is that urban governments, relative to central governments, may well have a shortage of administrative ability, and therefore may not be able to draw upon the available resources immediately. Another is that capital outlays needed during the process of rapid urbanization may be large, and municipal governments in developing countries may well have neither the authority nor the ability to raise the required revenues for investment by borrowing in financial markets. In such cases, there is good reason for some reliance on financing by a higher level of government through grants or direct expenditure.

Urbanization and Levels of City Expenditure

That the accumulation of people in a small area leads to the need for additional public services cannot be questioned. The disposal of human wastes and garbage becomes a problem. Movements of individuals in an urban area must be coordinated by public transportation, or streets will become overcrowded. Streets must be maintained. Disease prevention and treatment services must be on a higher level, since the increased population density facilitates the spreading of infectious diseases. Crime prevention becomes more essential as strangers go unnoticed in urban neighborhoods and social pressures no longer provide an adequate deterrent. Urbanization is also likely to lead to increased expenditures on public utilities. Large capital outlays are required for water, electricity, and telecommunications systems, often run by the city government. Owing to the high unit costs that accompany small-scale production, many services are not possible in rural settings. But as urban populations increase, economies of scale can be realized and these services grow rapidly. These and other factors lead to an increase in public expenditure as urban populations grow.

It is reasonable to expect the need for local government services to be concentrated more heavily in the large urban areas of developing countries than in those of more developed countries. First, relative to the concentration of population in urban centers, ownership of motor vehicles is much more heavily concentrated in the urban areas of the developing countries than in the urban areas of developed countries. This leads to costs for traffic control, road and street maintenance, etc. Increased mobility and migration from villages to cities lead to the breakdown of extended family relationships — with a concomitant impact on the need for social welfare programs in urban areas. Piped water may become essential in order to avoid contamination — a significant change from rural and village water systems in developing countries. Local governments are at least partially responsible for dealing with these problems. Because of

these major changes that accompany a shift from a rural to an urban society, local government per capita expenditure in the large cities is frequently four or five times that of local government in general.

As urban growth continues, urban public expenditure becomes a large part of total public expenditure — whether these expenses are met by a municipal, provincial, or national government. Urbanization increases the costs of government, but it simultaneously increases government revenues, as the cities are the focus of economic development. This has been true since industrialization led to the development of European cities toward the end of the Middle Ages. The relationship between per capita gross domestic product (GDP) and the level of urbanization is striking, as shown in Table 1. In countries with per capita GDP below $100, 10.4 percent of the population, on average, was urban; where the GDP was more than $500, the percentage was as high as 68.1. Regional GDP figures normally indicate a concentration of production and income in urban regions. In the Colombian departments with the four largest cities, for example, 1964 per capita GDP exceeded the national average by 50 percent and was more than four times that in three of the more rural provinces.

TABLE 1: Developing Countries: Relationship Between Per Capita Gross Domestic Product (GDP) and Urban Population

Number of Countries	Per Capita GDP	Urban Population as a Percentage of the Total [1]
21	less than $100	10.4
22	$100-199	20.7
19	$200-299	39.4
11	$300-499	35.2
14	$500 or more	68.1

[1] Urban population includes all those living in the cities of 100,000 or more in 1970.

The question still arises as to whether the wealth of cities is likely to allow them to deal effectively with their needs. It may not. Much of the government revenue derived from urban areas flows to higher levels of government. These levels of government are neither compelled to return the funds in the form of grants nor to spend the revenues on urban services. Indeed, political unrest in outlying provinces may dictate that the funds be spent on military or agricultural projects outside the urban centers. The political structure

of the country may also have a rural bias, with underrepresentation of the urban centers. Countries where this has occurred include France, the United States, and perhaps India. A major problem with such arguments is, of course, that it is exceedingly difficult to measure government expenditure that benefits a certain area relative to the revenues derived from that area. Such measurements must be based on tax burden and expenditure benefit assumptions, and the results are likely to be highly dependent upon these assumptions.

Decentralization

In developing countries, no level of government is likely to have a surplus of revenues or administrative talent. The question, which thus arises, is how best to meet the needs of the cities within the existing economic, political, and social constraints. In particular, to what extent can this end be most efficiently accomplished by "decentralization," or the allocation of decision-making responsibility or power to subnational levels of government? An increase in the quantity of local government resources and/or local government authority to utilize those resources freely means great decentralization.

The devolution of increased powers to city authorities may prove beneficial for a number of reasons. (1) City officials, through their more intimate knowledge of the tastes and wishes of local inhabitants, may best be able to meet the needs of their constituents. (2) Provision of services by local authorities can also ensure greater diversity in the quantity and quality of government services. (3) In many countries, tax consciousness is at a low level. In order to expand the public sector, it may be necessary to develop closer ties between tax revenues and benefits, and this can perhaps best be done at local levels. (4) Government bureaucracies in many developing countries can stifle, as well as facilitate, the conduct of business. Decisions made at the local level may put an end to a long chain of command and the related paperwork and delays. (5) Administrative resources and initiative are limited in all developing countries, and an increase in local authority may allow local talents to be utilized more fully. (6) Increased local responsibility may facilitate experimentation, resulting in greater efficiency in the provision of government services. All these arguments as well as equally important political and social reasons suggest that greater authority for city government may improve the public services.

On the other hand, strong arguments are made for increased centralization of government authority, as this may facilitate the achievement of greater economic stabilization, more equitable distribution of income, and greater uniformity in the provision of public services.

However, it seems unlikely that decentralization in any developing country will be so extensive as to seriously threaten the stabilizing role of the central government. In many developing countries, increased equality in incomes and wealth is viewed as a goal that is secondary to increasing the rate of economic growth; but it seems improbable that the likely degree of decentralization will seriously reduce the central government's ability to redistribute income if it wishes to do so. Some people have also claimed that the centralization of fiscal powers in developing countries facilitates economic planning, and thus nation building. However, the extent to which centralization facilitates planning is far from clear. Finally, a high degree of centralization might also be justified on the grounds that subnational governments have little administrative capacity. This is true, but every effort should be made to use the administrative capacity that the lower levels possess; to some extent, decentralization may increase the amount of administrative resources that are available at the local level.

In addition, a number of forces are likely to lead to increasing centralization, or to prevent any reduction in centralization, regardless of the original situation. First, higher-income levels accompanied by increased mobility of resources lead to a demand for greater uniformity in the provision of public services throughout the nation. Second, if the central government uses the more progressive taxes, growing incomes (probably helped along by inflation) will lead to an increase in the share of the economy's resources that are controlled by the central government. Third, the elites of new states may overreact to any move toward local autonomy, which they often see as subversive of national unity, the consequence being increased centralization.

A fourth factor that may inhibit any decrease in centralization is the likely concentration of administrative resources in the hands of the central government following independence. The central government's control over revenue sources makes it likely that it will pay the salaries and benefits that attract these scarce resources. Concentration of administrative resources may inhibit future decentralization even when nation-building objectives are met and greater decentralization becomes desirable. Finally, centralization is further facilitated by international aid. Foreign governments and international agencies deal with the central government, help to improve central government programs, and provide training for central government officials.

There are thus significant noneconomic as well as economic forces that can lead to an excessive and perhaps increasing degree of centralization in developing countries, while forces in the reverse direction are not as apparent, despite the possible benefits

of more decentralization. As a result, it is likely that centralization of fiscal powers in many developing countries is already excessive, although in some it may still be insufficient.

City Expenditure

Problems with measuring expenditure patterns. Before the data are examined, some of their shortcomings are noted to ensure that conclusions drawn from the data are treated with the appropriate degree of caution. First, expenditure frequently is not carefully and uniformly allocated by function. Many variations of this problem exist: (1) "General administration" in some cities may include expenditure on courts and police that is specially allocated by function in other cities. (2) Where functional breakdowns do exist, different countries may use different terms to refer to expenditure for the same function, or the identical term to refer to expenditure for different purposes. For example, what part of public works expenditure is for roads, streets, water systems, school buildings, etc. ? (3) In cities in at least two countries, separate supplementary payments are made to present and/or past employees as part of their remuneration, and these payments are not allocated by function. (4) The "other expenditure" category is frequently large in city data. This appears to be a particular problem in Brazilian cities where 45 percent or more of total expenditure cannot be allocated by function on the basis of available data. In other cities, even though information on current expenditure may be available by function, capital expenditure information is not. (5) In several instances, two or more functions were lumped together in data relied upon for this study.

Second, it is often unclear which publicly run enterprises should be considered as part of the public sector and which should be considered as part of the private sector. For example, in the Indian cities, enterprises providing electricity and telephones may be controlled either by the municipality, by the state, or by private corporations. In Lagos, Nigeria, the responsibility for providing water is divided between the city and the Central Government. In the three Colombian cities, municipal enterprises have the primary responsibility for providing electricity, telephones, and water. Their finances are recorded in such a manner that their revenues equal expenditure, and they make no net contribution to municipal revenues. By excluding the gross municipal expenditure on utilities, the relative importance of other expenditure categories rises in Colombian cities vis-à-vis cities in other countries.

Third, subtle differences in the form of central government aid may lead to large apparent differences in the relative importance of a given function in overall municipal expenditure. For example, in Colombo and in Mexico City the fact that the Central Government is

responsible for education causes other expenditure to appear relatively more important. However, it must not be concluded that the absence of a particular function from the local budget means that the function has been assigned to higher levels of government. In Seoul, local school authorities exist separately from other local authorities, and education remains very much a responsibility of the local community.

Expenditure patterns. Table 2 provides a few insights into municipal expenditure patterns although, for the reasons mentioned, the data must be interpreted cautiously. Apparently, four categories normally account for the bulk of total municipal expenditure — general administration, public health, education, and public works. (Where possible, public works expenditures are allocated by function; for example, school construction is under education when separately designated.)

Expenditure on general administration is inevitably a large part of the cost of municipal government. Some evidence exists to support the proposition that administrative expenditure as a share of the total may vary inversely with the wealth of the city. This expendicture is subject to significant economies of scale, since, even in the poorest large city, an administrative system must be able to provide a minimum of health, sanitary, education, and maintenance services. Nevertheless, some of the figures are clearly not explained by this argument — for example, the relatively large share spent on general administration in Mexico City. In some cities the administration is more efficient; also, overhead expenditure may be more fully allocated to the various city function.

Given these qualifications, evidence appears to support the proposition. Perhaps most obvious is the difference between the share spent on general administration in the 27 developing cities (20.8 percent) and in the 3 cities in the developed world (2.3 percent). Within geographical areas there also appears to be an inverse relationship between municipal per capita expenditure and the share of total expenditure used for general administration. For example, Seoul and Singapore have by far the highest per capita expenditure of the Far Eastern cities and spend a significantly smaller share for general administration. The same is true for Bombay among the Indian cities, Nairobi in Africa, and São Paulo in Brazil. Evidence appears to lend some support to the position that the poorer the city, the more closely it resembles an employment service: that is, the percentage of municipal resources devoted to shuffling papers is large, while the percentage devoted to providing services to the public is relatively small.

Revenues devoted to health services, as a share of total municipal

resources, also vary tremendously among the municipalities of the world, ranging from 2 to 30 percent. Bangkok, Saigon, and the Indonesian cities all have the responsibility to provide clinics, dispensaries, and medical services. In Bangkok and Saigon, where per capita expenditure is much higher than in Djakarta, the percentage of total municipal expenditure allocated for public health purposes is also much larger. South Asian variations in health expenditure as a percentage of total expenditure are relatively small. In the three African cities of Dar es Salaam, Lagos, and Nairobi, public health accounts for between 20 and 30 percent of total expenditure.

TABLE 2: Distribution of City Expenditure by Function as a Percentage of Total Expenditures

City	Year	General administration	Public health	Education	Roads and highways	Sanitation and sewage	Water	Electricity	Public works[a]	Debt charges	Courts, police, and public safety	Fire	Welfare	Housing	Transport and communications	Other expenditure	Other capital expenditure[b]
Africa																	
Dar es Salaam	1965	13.3	28.2	25.6					24.8	7.1						1.0	
Freetown	1964	28.3	2.1	28.5	22.5							6.6				12.0	
Lagos	1963	13.7	30.0	21.0	20.8		←——1.9——→									13.2	
Nairobi	1965	9.5	19.8	20.9	17.4	7.8					1.2			15.6		7.9	
Far East																	
Bangkok	1968	27.8	14.9	17.0					34.0	1.9						4.4	
Djakarta	1971	29.2	2.1	18.5	0.2	1.7			14.8		1.2	0.7				31.5	
Semarang	1970	27.3	5.3	6.0					11.1		5.7			2.9	14.4	27.3	
Solo	1970	33.4	3.9	3.9			←——1.4——→		8.3		1.2			1.9	6.2	39.8	
Manila	1967	9.0	7.8	36.8		6.2			6.7		16.2	3.9	2.4			11.0	
Saigon	1969	13.4	24.6	25.6					18.1			5.0				13.2	
Seoul	1970	5.1	2.6	18.6	0.2	4.5	←——9.0——→		28.6		←——0.4——→		1.5	7.4	1.8	20.2	
Singapore	1969	11.5	10.0	20.9					4.3		24.8	0.4	2.3		4.5	22.3	
South Asia																	
Ahmedabad	1968	12.3	36.9	20.1					4.2	23.0	←—— 3.0——→					0.5	
Bombay	1968	5.4	31.3	19.6					9.7	21.3	←—— 11.2——→					1.6	
Calcutta	1968	36.3	27.9	3.8					6.8	3.9	←—— 5.2——→					16.1	
Hyderabad	1967	17.1	22.7	0.5					22.7	2.3	←——25.5——→					9.2	
Madras	1968	6.6	17.8	18.0					18.9	4.1	←——19.8——→					14.8	
Colombo	1968	33.5	24.3				5.8		18.5		0.2	1.6	8.5			1.9	5.5
Latin America																	
Belo Horizonte	1968	21.1	5.2	10.2									18.6		0.4	44.3	
Recife	1968	31.5	2.9	5.1									14.6			45.9	
Rio de Janeiro	1968	40.9	11.4	16.2							0.2		11.6		11.1	8.6	
São Paulo	1968	10.5	5.2	10.6							—		6.2		12.1	55.4	
Bogotá (D.E.)	1969	26.3							17.2	3.5					8.9	35.0	9.0
Cali	1969	24.0							46.3	4.0						10.6	15.1
Medellín	1969	22.3							16.9	6.1						25.7	28.9
Mexico (D.F.)	1962	38.3				←——19.0——→			26.7		3.7					12.3	
Venezuela (D.F.)	1969	15.1	25.9	6.4		10.7			9.9		21.2					10.8	
Developed countries																	
New York City	1969	2.1	10.0	20.6	3.3	2.8	1.1			3.0	5.8	2.5	21.4			27.4	
San Francisco	1969	2.6	6.3	15.0	2.1	1.2	4.2			1.1	3.5	3.1	11.5			49.5	
Stockholm	1968	2.3	18.7	12.2	10.9		2.8	9.0[c]		10.4		0.5	13.8		4.3[d]	15.2	

Expenditure for education ranges from one sixth to one fourth of total municipal expenditure in Bangkok, Djakarta, Seoul, and Saigon. Although the two smaller Indonesian cities of Semarang and Solo retain the responsibility for primary schooling, expenditure for education remains relatively unimportant, accounting for 6 percent or less of

their total expenditure. The city of Colombo in Sri Lanka spends nothing on education, since it is the responsibility of the Central Government. In India, expenditure for education by the municipal corporations varies from 0.5 percent of total city expenditure in Hyderabad to 20.1 percent in Ahmedabad. It is evident that in the poorer municipalities, owing to lack of resources, either the burden of financing education rests with the states or education is not provided. Evidence suggests that the low priority placed on education by the poorer municipalities is not compensated for by higher per capita expenditure by the state. In 1967-68 per capita state expenditure on education was lowest in Andhra Pradesh (Hyderabad) and West Bengal (Calcutta), and highest in Tamil Nadu (Madras) and Maharashtra (Bombay).

In the African cities, the relative importance of expenditure on education appears fairly comparable, accounting for between 20 and 30 percent of total city expenditure. The means of financing the expenditure vary considerably, however. Expenditure on primary schools in Nairobi is financed primarily by personal tax revenues and tuition fees. In the towns and cities of Tanzania, a central government subvention accounted for about 85 percent of current education expenditure. In Lagos, 70 percent of recurrent expenditure and 100 percent of capital expenditure were met by grants; in Freetown, the Central Government covered 100 percent of the salaries of primary teachers and 60 percent of capital expenditure.

It is difficult to generalize about other categories of expenditure; expenditure on public works deserves mention, however, as its importance had been emphasized in earlier sections. For some of the cities, outlays for public works are allocated by function in Table 2 — as in Freetown, Lagos, and Nairobi. In other cities, at least some of the expenditure on these items has been included in public works, such as sidewalks and roads in Bangkok, and roads, sewers, sidewalks, parks, etc., in the Colombian cities. However classified, most cities in developing countries have had to allocate a significant part of their budget to capital projects. Such expenditure ranged from one third to one half of total expenditure in Bangkok, Mexico City, and Cali. In other cities, capital outlays may have been equally important, but because of the allocation of expenditure by function they are not so readily apparent. Finally, Table 2 indicates that expenditure on welfare was signigicant only in Colombo, the Brazilian cities, and the cities in the developed countries.

Per Capita Expenditure and Revenue Comparisons

Table 3 indicates that among the Far Eastern cities, those in Indonesia are lagging in per capita revenues and expenditure. In

Djakarta, per capita revenues in U. S. dollars are only slightly in excess of half those in Bangkok and are almost one third those in Manila. The same is true for per capita expenditure. To the extent that Djakarta can provide the same services at a fraction of the cost, this type of comparison is not very useful. For example, salaries of school teachers and health personnel will depend in part upon per capita income and general living standards in the country; however, some of the services require modern construction materials and equipment that may have comparable costs in terms of U. S. dollars in these cities. Seoul's per capita expenditure is, with the exception of Singapore, more than two and a half times that of any of the other Far Eastern or South Asian cities. Singapore is a city-state, has no legal restrictions imposed by higher levels of government on its revenue sources, and has full responsibility for all public services. This situation coupled with a relatively high per capita income level helps to explain why Singapore's per capita expenditure is nearly four times that of Seoul.

A large variation also exists in the per capita revenues and expenditure of the African cities. Per capita expenditure in Nairobi is five times that in Blantyre, three and a half times that in Dar es Salaam, three times that in Lagos, and more than double that in Freetown, keeping in mind that the years are not the same for all cities. Although separate expenditure data for Lusaka were not obtained, it appears from the revenue figures that per capita expenditure in Nairobi was about one and a half times as great as that in Lusaka.

Perhaps of greater interest is the disparity in urban expenditure within countries. Variations in responsibilities and costs, although sometimes still important, will be less than in the intercountry comparisons, and therefore the intracountry comparisons should provide a more accurate picture of differences in the services provided. For five Indian municipal corporations examined, per capita expenditure ranged from $2.59 (Hyderabad) to $10.43 (Bombay). The variation is considerably less among the four Indonesian cities examined. Differences in per capita expenditure are large in both the Brazilian and the Colombian cities. In Brazil, São Paulo's per capita expenditure ($38.09) is more than triple that of Belo Horizonte ($11.57) and Recife ($10.70). Rio de Janeiro, since it has a dual status as the State of Guanabara, can be compared with the others only if the per capita expenditure of respective state governments is added to that of the three cities just named. This results in the following per capita expenditure: São Paulo, $112.11; Rio de Janeiro, $82.32 ; Belo Horizonte, $30.44; and Recife, $26.55. In Colombia, per capita expenditure by the municipal governments in Bogotá and Medellín is roughly similar, with Cali's expenditure being about half that of the other two.

Some of the variation in per capita city expenditure within coun-

TABLE 3: Per Capita Expenditure and Revenues in Terms of U. S. Dollars

City	Year	Per Capita Expenditure	Per Capita Revenues	Per Capita Revenues Net of Grants	Exchange Rate Used (Currency Unit Per U.S. dollar)	National Per Capita Income (U.S. dollars)
Africa						
Blantyre	1965/66	8.12	8.91	8.79	0.3571	135
Casablanca	1968	21.93	22.93	—	5.08	188
Dar es Salaam	1965	11.74	11.55	9.83	0.3715	66
Fort Lamy	1970	14.56	11.10	5.14	277.71	63
Freetown	1963/64	15.35	15.35	10.25	0.3571	138
Lagos	1962/63	14.17	11.29	6.78	0.3571	70
Lusaka	1967	—	31.00	25.54	0.3571	245
Nairobi	1965	42.99	42.96	42.96	0.3571	111
Far East						
Bangkok	1968	10.16	10.56	8.51	20.85	146
Djakarta	1970/71	4.70	5.74	4.50	375.00	89
Makassar	1969/70	—	2.05	1.32	375.00	87
Semarang	1969/70	1.94	1.83	1.48	375.00	87
Solo	1969/70	2.00	1.89	1.32	375.00	87
Manila	1964	—	16.54	16.34	3.93	245
Saigon	1969	7.45	11.60	11.60	118.00	—
Seoul	1970	29.97	31.22	27.71	316.00	179
Singapore	1969	115.05	143.14	—	3.09	779
South Asia						
Ahmedabad	1967/68	8.39	7.18	6.68	7.547	96*
Bombay	1970	13.65	11.83	11.89	7.559	129*
Calcutta	1967/68	4.32	4.04	3.48	7.547	113*
Hyderabad	1966/67	2.59	2.71	2.68	7.576	70*
Madras	1967/68	6.49	5.90	5.80	7.547	81*
Colombo	1968	10.89	12.26	9.31	5.940	147
Latin America						
Belo Horizonte	1968	11.57	14.52	7.75	3.83	179*
Recife	1968	10.70	11.51	3.47	3.83	148*
Rio de Janeiro	1968	82.32	79.06	75.22	3.83	570*
Sao Paulo	1968	38.08	38.09	20.23	3.83	434*
Bogtá (D.E.)	1969	28.16	28.16	24.21	17.93	474*
Cali	1969	13.28	11.44	11.13	17.93	381*
Medellin	1969	25.82	24.30	24.01	17.93	301
Dominican Republic (D.N.)	1966	15.17	14.67	6.44	1.00	258
Guatemala City	1962/63	—	8.76	8.76	1.00	261
Mexico (D.F.)	1963	23.51	27.07	27.07	12.49	414
Montevideo	1958	12.03	12.03	12.03	10.20	653
Panama City	1968	9.51	8.42	8.32	1.00	567
Valencia	1964	—	13.36	11.64	4.50	899
Venezuela (D.F.)	1969	48.02	46.09	24.24	4.50	948
Development Countries						
New York City	1969	888.50	828.80	458.50	1.00	3,521
San Francisco	1969	1,090.50	965.90	590.50	1.00	3,521
Stockholm	1968	1,391.06	1,357.66	1,194.11	5.18	2,571

*Per capita income for the state or department in which the city is located.

tries, as well as among countries, is undoubtedly due to variations in per capita income. For example, although supporting data are not available, average per capita income is probably somewhat higher in Djakarta than in the other Indonesian cities examined here.

Per capita figures for the states of India indicate that of the states in which the five Indian cities examined are located per capita income in Maharashtra (Bombay) is the highest and in Andhra Pradesh (Hyderabad), the lowest. Likewise, per capita income in São Paulo (state) and Guanabara (Rio de Janeiro) is about three times that in Pernambuco (Recife) and Minas Gerais (Belo Horizonte). Data for the African cities are lacking, but it seems clear that the per capita incomes in Nairobi and Lusaka significantly exceed those in the other African cities and may be partly responsible for the higher level of expenditure in these two cities. Finally, it may be of some interest to note that for two cities cimilar in size, Djakarta (1971 population of 4,576,009) and Rio de Janeiro (1968 population of 4,132,000), per capita expenditure by local governments was $4.70 and $82.32, respectively. Tremendous variation exists among the cities of the world, and it is beyond the scope of this study to explain all the factors leading to the differences in the numbers presented in the preceding tables.

City Revenues

Revenue patterns. Table 4 depicts the basic patterns existing in municipal revenues around the world. Uniformity is clearly lacking. In many countries the British introduced the property tax as a principal revenue source. In none of the Asian or African cities that came under British influence (except in the special case of Singapore) do taxes on property account for less than 27 percent of total revenue (see Table 4). The average reliance on property taxes by the 12 South Asian and African cities plus Singapore is 43.2 percent. This is all the more striking when it is seen that the 8 other cities of the Far East and the 10 Latin American cities examined derive, on average, only 11.4 percent and 26.4 percent (valorization included), respectively, of total revenues from taxes on property. Fort Lamy, the one city in French-speaking Africa that is covered here, raised only 5.4 percent of its total revenues from a property tax.

The second major tax source relied upon by cities in this sample is some type of sales tax levied on gross business sales or assets, as in Brazil; on some combination of gross sales, rent, square footage, and horsepower, as in Colombia; or on gross receipts, as in Bangkok. Another form of indirect tax, the octroi, is levied by Indian municipal corporations. For those cities employing a sales or excise tax, the relative importance of this source varies tremendously — from 5.6 percent in Recife to 47.9 percent of total revenues from the octroi in Ahmedabad, India. Many cities, however, ignore these forms of indirect taxation. These taxes are noticeably absent in the African cities in this study, except for Fort Lamy, which raised 8.9 percent of its revenue from a turnover tax. In most countries, including India and Brazil, the more general types of sales tax are

TABLE 4: Sources of City Revenues, Selected Years (In Percent)

City	Year	Taxes on Property (1)	Sales and Excise Taxes (2)	Vehicle Taxes (3)	Entertainment and Gambling Taxes (4)	Other Taxes[a] (5)	Total Taxes (6)	Licenses, Fees, and Charges (7)	Income from Interest, Investments, Rentals, and Sale of Property (8)	Other Income[b] (9)	Total Nontax Revenue (10)	Shared Taxes and Grants (11)
Africa												
Blantyre	1966	60.4				0.3	60.7	28.0		10.2	38.2	1.1
Dar es Salaam	1965	36.9				4.1	41.0	44.1			44.1	14.9
Fort Lamy	1970	5.4	8.9	1.2	4.0	4.5	24.0	6.5		15.6	22.1	53.7
Freetown	1964	52.1				1.4	53.5	8.8	2.6	2.3	13.7	32.8
Lagos	1963	50.9					50.9	9.1			9.1	40.0
Lusaka	1967	50.0				5.2	55.2	←——27.3——→			27.3	17.6
Nairobi	1965	28.7				29.1	57.8	39.4	2.8		42.2	0.0
Far East												
Bangkok	1968	15.0	39.1	6.0[c]	5.0	10.2	75.3	3.0	0.1	2.1	5.2	19.5
Djakarta	1971	2.0		26.1	27.1	4.2	59.4	1.6		10.5	12.1	28.5
Makassar	1970	6.0			16.8	6.0	28.8	33.0		2.7	35.7	35.5
Semarang	1970	12.9		0.9	6.3	36.7	56.8	13.0		11.2	24.2	19.1
Solo	1970	8.7		0.3	3.4	12.0	24.4	9.5		35.7	45.2	30.6
Manila	1964	21.7	10.7			1.7	34.1	27.1		12.4	39.5	26.4
Saigon	1969	9.4	40.3			8.1	57.8	8.1	12.7	21.4	42.2	0.0
Seoul	1970	15.2[c]		6.6	5.5	2.8	30.1	←——47.3——→		7.1	54.4	15.3
Singapore	1969	11.1	24.1	5.0	2.0	30.1	72.3	18.5	9.2	—	27.7	0.0
South Asia												
Ahmedabad	1968	27.9	47.9	2.7			78.5				14.5	6.9
Bombay	1970	45.0	25.7	2.2	0.2		73.1	25.9	1.0	0.0	26.9	0.0
Calcutta	1968	65.0		0.4		6.3	71.7				14.4	13.9
Hyderabad	1967	32.0		2.8		29.1	63.9				35.1	1.0
Madras	1968	40.0				32.9	72.9				25.6	1.5
Colombo	1968	61.0					61.0	4.3		8.1	12.4	26.7
Central America												
Dominican Republic (D.N.)	1966	0.7			0.6		1.3	34.1		8.3	42.6	56.0
Guatemala City	1963	20.7	11.3	3.5		18.5	54.0	38.2		7.8	46.0	0.0
Mexico (D.F.)	1963	26.2	32.4	—	2.3	9.5	70.4	15.4		14.2	29.6	0.0
South America												
Belo Horizonte	1968	22.2	6.5			0.2	28.9	9.1		15.6	24.7	46.5
Recife	1968	9.9	5.6			0.2	15.7	5.3	0.2	8.9	14.4	69.9
Rio de Janeiro	1968	0.7	70.4			10.7	81.8	5.1	4.1	4.1	13.3	4.8
São Paulo	1968	17.2	10.9			0.4	28.5	9.9	0.5	14.2	24.6	46.9
Bogotá (D.E.)	1969	30.2	8.5	1.7	1.6	1.8	43.8	38.6		3.4	42.0	14.0
Cali	1969	67.2	12.0	1.6	2.6	1.3	84.7	8.6	0.3	3.6	12.5	2.7
Medellín	1969	35.1	13.7	0.0	1.1	1.3	51.2	22.8	4.7	20.2	47.7	1.2
Montevideo	1958	60.2		10.6		7.1	77.9	5.3		16.8	22.1	0.0
Valencia	1964	13.0	28.8	6.9	2.5	7.7	58.9	21.4		7.1	28.5	12.8
Venezuela (D.F.)	1969		17.7	2.6	1.0		21.3	0.3	0.5	30.5	31.3	47.4
Developed countries												
New York City	1969	25.7	9.4			8.3	43.4	9.6		2.4	12.0	44.7
San Francisco	1969	38.4	4.8			0.4	43.6	10.0		7.4	17.4	38.9
Stockholm	1968					38.3	38.3	33.4		16.3	49.7	12.0

reserved for the central or state levels of government.

Four of the cities included in the sample levy some form of income tax. In 1969, New York City gained about 8 percent of its total revenues from income tax, and Stockholm derived 38 percent from that source in 1968; however, from the developing countries, Nairobi, Lusaka, and Singapore are the only cities in the sample that use some form of income tax. Nairobi until recently levied a tax on income at a fixed rate, and raised as much from this source in 1965 as it did from property taxes — about 29 percent of total revenues. Lusaka raised about 5 percent of total revenues from a personal levy.

Two other tax sources singled out in Table 4 are Vehicle Taxes and Entertainment and Gambling Taxes. Only in rare cases are these major municipal revenue sources. Most cities derive some revenue from vehicle taxes (including some African cities where vehicle taxes are lumped with "Other Taxes"). In Djakarta, vehicle taxes account for one fourth of total city revenue; this is due partly to the insignificance of property and sales taxation as revenue sources. Other cities that draw somewhat disproportionately large amounts from vehicle taxation are Seoul, Montevideo, and Cairo. In Thailand and Tanzania, revenues from motor vehicle licenses are shared with city governments, and in the Philippines and Brazil, the municipalities are given a share of central government tax revenues from motor vehicle fuels.

Gambling and entertainment taxes have been a major revenue source for Djarkarta and Makassar in Indonesia. These two cities gained 27.1 percent and 16.8 percent, respectively, of their revenues from taxes on casinos, lotteries, and other forms of entertainment. In no other city do these taxes appear to raise more than 7 percent of total revenues, although they appear to be one of the revenue sources more or less universally relied upon by local governments. Administration is simplified by the fact that there are likely to be relatively fewer taxpayers, and checks for tax avoidance can be made more easily.

Few details can be given about the "Other Income" category because in most of the data sources it is not broken down. Table 4 indicates that grants from higher levels of government (column 11) generally form an important part of municipal revenues in all parts of the world.

Suggestions for City Revenues

Administrative resources have frequently been thinly spread, and revenue sources normally have not been developed to anywhere near their full potential. This may be due partly to the susceptibility of local officials to pressures from potential taxpayers. If the alterna-

tive to higher local taxes is an increase in central government taxes and greater aid to the cities, the city official may find that increase preferable. The large number of revenue sources frequently drawn upon also suggests that it may be easier to find new minor sources of revenue than to allow the effective rates of some taxes to grow to noticeable levels through rate changes or improved enforcement. This path of action holds the added attraction that more civil servants are needed to generate the same amount of revenues. It is only realistic to recognize that such forces are likely to have played an important role in the evolution of existing city revenue systems. As the demand for urban services becomes more urgent, however, and as the inadequacies of higher-level governments in meeting these demands increase and are recognized, the possibility of changing and improving city revenue systems is enhanced.

This appears to be the current situation, and it is one in which it is useful to seek the most promising avenues open to the cities in the developing world. Clearly, the appropriate avenues depend on the capabilities of city administrators and on other constraints on the city governments. The following suggestions, of course, will not be equally appropriate for all cities. In decreasing order of potential, the following taxes appear to hold the greatest promise for city governments in developing countries: taxes on property, on sales or trading licenses, on motor vehicles, and on amusements. The potential of each of these taxes has been demonstrated effectively in various cities in the developing world: for example, the property tax in Lusaka, Nairobi, and Mexico City; taxes on sales or trading licenses in Bangkok, Mexico City, and the cities in Colombia and Venezuela; motor vehicle taxes in Djakarta and Montevideo; and amusement taxes (including gambling taxes) in Djakarta. It must always be kept in mind that the arguments for a strong "city" revenue base are inexplicably linked to those for the desirability of a measurable degree of decentralization.

The potential for property taxes and their ineffective use in many parts of the world has been noticed. For example, a recent intensive study of the property tax system in Djakarta, where property taxes raised only 2 percent of total city revenues, concluded, not surprisingly, that property taxation could and should be strengthened. A 1969 study of local finance in Korea recommended approximately a tenfold increase in property taxes over a five-year period. Weaknesses in property taxation have not been overlooked by experts examining this tax in South and Central America, either. In Colombia, Mexico, Panama, and Venezuela, experts have emphasized the importance of more effective use by local governments of property taxes as a source of local revenue. If property taxes — unlike sales, income, or motor vehicle taxes — are not used by local

authorities, they are probably ignored by other levels of government.

Increased use of betterment levies may also be a way to effectively tax property owners and to finance urban improvements (see next article). The major cities in Colombia have found that significant capital improvements can be financed locally if property owners benefiting from the projects are required to pay a tax equal to some part of the increase in the value of their property resulting from improved streets, parks, or sidewalks. Similar forms of tax have been used in Ecuador and the Federal District of Mexico, and special assessments have been widely used to finance improvements in other developing countries, although they have generally raised only small amounts of revenue. Betterment levies and special assessments are a means of assuring that urban revenues will be used for specific purposes. They differ from some forms of earmarked taxes as they tend to be levied for a definite period, with the objective of recovering the cost of a specific project. They do provide useful evidence, however, that earmarking of taxes might be used effectively to finance various city services.

Sales taxes at the municipal level have received less attention from technical assistance experts than have property taxes. This is due to the complex way in which existing taxes have frequently been administered, the difficulties in improving markedly upon the existing systems, and the allocation of this form of tax to higher levels of government. In Colombia, where the business and industry tax is highly complex, it raised 27 percent of the combined tax revenues of the four largest cities in 1967. Rather than abolish such a lucrative tax, one fiscal expert recommended a 2 percent municipal retail sales tax, with a few items, such as food and clothing, exempt. In addition, those businesses with gross sales below a certain level could be exempted. In Bombay and Caracas, where complex forms of the sales tax have also provided significant city revenues, fiscal experts have argued, among other things, for simplified rate structures rather than for eliminating existing taxes. On the one hand, the relatively high income elasticity of the sales tax is a particularly attractive feature for municipal governments; on the other hand, the potential for evasion and corruption in its use in developing urban areas cannot be denied, and appears to have been a major consideration when one group of fiscal experts recommended the elimination of the tax in Panama. The types of sales and business license taxes used have also been charged with contributing to regressivity and with inhibiting the efficient allocation of resources.

Fiscal experts have been less critical of the use of the vehicle tax by cities for three reasons: (1) administrative problems of vehicle taxes are considered less serious; (2) various forms of the tax are viewed as a means of improving on existing resource allocation; and

(3) vehicle taxes are frequently considered to be a progressive form of taxation. Two frequent recommendations are for higher rates and for increased uniformity of rates (particularly in small countries). As with property taxes, there appears to be general agreement concerning the usefulness of motor vehicle taxes as a source of city revenues. Much of this agreement may well be based on the heavy concentration of motor vehicles in the major cities in developing countries, the revenue potential of congestion charges, and the costs generated by the existence of these vehicles. There also appears to be increasing recognition that only through effective vehicle taxation, which may well include congestion charges, can developing cities hope to control the use of private transport and to create a viable system of public transport in the long run.

Amusement taxes and the like generally are administrable locally and are not open to serious question on grounds of equity. Levied at relatively low rates on nonessentials, this form of taxation is perhaps least likely to be usurped by higher levels of government. If exploited effectively, it can serve as a significant and dependable revenue source.

There is a case to be made for the use of many other city taxes, as well as for the proper pricing of public services, and most cities will no doubt continue to use a wide range of revenue sources. In the long run, however, cities should probably begin to concentrate their scarce administrative resources on the collection of a small set of taxes, rather than continuing the never-ending search for new sources of revenue which invariably yield only small amounts.

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Urban Finance in Seoul

Roy W. Bahl and Michael J. Wasylenko

[Seoul, Korea, is a very large and fast growing city which has been quite successful in finding ways to finance its expanding needs despite the relatively low per capita income of its inhabitants. The methods used should be of interest to cities confronting similar problems.]

Seoul, the capital of South Korea, has a population approaching six million, and is one of the largest cities in the world. The composition of employment in metropolitan Seoul shows that its economic base is dominated by trade, services, and government — only approximately two of every ten employed persons work in the manufacturing sector. The level of income was $390 per capita in 1970. The rate of population in-migration to Seoul has been substantial, as evidenced by the differential between the average annual population growth rate of the nation as a whole (2.3 percent) and that of Seoul (10.2 percent). This rapid growth in population places a strain on existing infrastructure, adds to capital expenditure needs, and creates pressures on the level of current expenditures. When in-migrants are relatively lower income families, the growth of tax base due to in-migration may not be adequate to cover the increased expenditure demands. The level of public infrastructure in Seoul is still inadequate and in need of expansion. Nevertheless, the city has made considerable progress in mobilizing its financial resources, and meeting the needs of its fast growing population. (Note: the government of Seoul Special City, abbreviated here to SSC, covers a large metropolitan area

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around the city center, and has a special status at the provincial level reporting directly to the Prime Minister rather than the Interior Ministry.)

Budget Structure

The budget of Seoul Special City is structured around three sets of accounts: a general account, an education special account, and a set of 12 other special accounts. These apply to specified activities, such as water supply, sewage, public housing, land development units, toll roads, river development, etc. Within budget categories there is no distinction between current and capital expenditures; but the general account is primarily current, and the special accounts are primarily capital expenditures. Within the education special account both current and capital expenditures are substantial.

A clear analysis of SSC activities by function is difficult, primarily because the budget is less consistently oriented toward a functional breakdown than toward a departmental or bureau breakdown. For instance, there are expenditures for road and street maintenance included in both the general and special accounts, and under heads such as "city planning" and "construction works." In order to obtain a functional breakdown of expenditures, a compatible set of expenditure functions and budget categories was developed by local authorities especially for this study.

Expenditures of Seoul Special City

From 1963 to 1972 the annual rate of increase in per capita expenditures of the SSC government was 34.5 percent. This dramatic annual growth in SSC expenditures has been greater than the rates of increase in either the city's population (8%) or in the price level (12%); thus, the levels of both per capita and real spending have risen. (After adjustment for the rate of price increase, real expenditures of the SSC increased at a rate of 22.5 percent per year between 1963 and 1971.) Per capita income in the SSC area was estimated to be growing by about 25 percent annually, somewhat less than the growth in SSC spending. The rate of expenditure increase of the SSC government is also high by comparison with rates of increase in the spending levels of the central government (about 23 percent a year) and of other local governments in Korea.

Structure of expenditure increase. The expenditure of the SSC government has been characterized by a relatively heavy and increasing emphasis on capital spending, a declining expenditure share for the social services (education, health, and welfare), and a large and growing share of expenditures on specific projects and/or public enterprise activities. Two years, 1963 and 1970, are disaggregated

here by both function and current-capital status. About 70 percent of the total expenditure increment over the 1963-1970 period is due to rising capital expenditures, with the result that by 1970 capital spending accounted for 65.2 percent of the total budget. Nevertheless the current expenditures of the SSC government grew at the very rapid annual rate of 22 percent, largely because of heavy increases in current spending for health services and education.

Table 1: Functional Distribution of SSC Expenditures, 1963 and 1970

Function	% of SSC Expenditure 1963 Current	1963 Total	1970 Current	1970 Total	% of Increase in Total Expenditure
Water Supply	11.4	15.3	16.1	11.7	11.3
Sewerage	.0	2.7	.0	3.5	3.6
Refuse Collection	6.5	3.3	9.0	4.0	4.1
Roads & Bridges	.0	17.3	.1	21.2	21.6
Transportation	.5	.3	4.7	2.0	2.2
Land Readjustment	.0	1.4	.0	6.4	7.0
Han River Construction	.0	.0	.0	8.3	9.3
Subtotals	18.4	40.3	29.9	57.1	59.1
Health	4.9	2.4	6.2	2.8	2.8
Education	44.7	25.1	36.3	19.7	19.1
Welfare	6.0	2.9	4.6	1.8	1.7
Housing	.3	12.6	.4	8.0	7.4
Subtotals	55.9	43.0	47.5	32.3	31.0
General Administration	21.6	11.6	19.3	7.3	6.8
Police	.0	.0	.4	.3	.4
Fire	.8	.5	.5	.3	.4
Industry	1.4	3.7	1.8	2.5	2.3
Debt Service	1.7	.8	.5	.2	.1
Subtotals	25.5	16.6	22.5	10.6	10.0

This heavier emphasis on capital expenditures over the 1963-1970 period gave rise to marked changes in the functional distribution of SSC government expenditures (see Table 1). In general, the share of SSC resources devoted to the social service type of activities (education,

health, welfare) tended to decline, as did that of administrative activities, while the share devoted to construction and infrastructure types of activities, particularly land adjustment, Han River construction and roads, increased.

The sources of finance. It is an issue of some policy importance to explain the factors which underlie such a rate of increase in the level of expenditure. Rapid expenditure increase could be attributed either to rising expenditure demands or to an increase in resource availability. It seems reasonable to argue that in a relatively poor but fast developing country the direction of causation runs from revenues to expenditures, so that a relaxation of the resource availability bottleneck seems the more likely explanation. If so, the key to understanding Seoul's rapid expenditure increase lies in understanding the sources of its revenue increase. A thesis offered here is that the rapid increase was due mainly to the ability of the SSC government to raise additional resources from undertakings that are partly or wholly self-financing.

The total amount of SSC expenditure increase over the 1964-1971 period is 58.6 billion won. The absolute amount of this increase has been growing at an increasing rate since 1964, with particularly

Table 2: THE FINANCING OF TOTAL EXPENDITURES 1964-1971
(In Millions of Won)

	1971	1970	1969	1968	1967	1966	1965	1964
Total Expenditure	64,327 (100)1/	49,510 (100)	37,689 (100)	28,844 (100)	17,293 (100)	13,154 (100)	7,320 (100)	5,685 (100)
Tax Revenues 2/	19,481 (30.3)	17,099 (34.5)	12,319 (32.7)	8,711 (30.2)	5,041 (29.2)	3,497 (20.2)	2,223 (30.4)	1,612 (28.4)
General Non-Tax Revenues 3/	8,652 (13.4)	8,013 (16.2)	6,141 (16.3)	4,004 (13.9)	2,407 (13.9)	1,938 (11.2)	1,569 (21.4)	2,144 (37.7)
Self-Financing Project Revenues	23,378 (36.3)	15,504 (31.3)	11,602 (30.1)	9,668 (33.5)	3,540 (20.5)	2,791 (16.1)	1,113 (15.2)	717 (12.6)
Revenues from Borrowing 4/	2,624 (4.1)	531 (1.1)	0 (0)	0 (0)	0 (0)	230 (1.3)	0 (0)	87 (1.5)
Grants in Aid	10,192 (15.8)	8,363 (16.9)	7,627 (20.2)	6,461 (22.4)	6,305 (36.5)	4,698 (27.2)	2,415 (33.0)	1,125 (19.8)

1/ Figures in parentheses are percentages of total expenditure in each year.

2/ Tax Revenues include these taxes: Acquisition Tax, Automobile Tax, Entertainment Tax, Slaughter Tax, Parimutuel Tax, License Tax, Property Tax, City Planning Tax, Fire Service Establishment Tax,

3/ Non-Tax Revenues include revenue from Property income, rents from land and housing, land building sales, rents and fees including revenues from Public Industry, Admission fees, Stamp Revenues, surplus receipts from previous years. Transfers from Special Account and other Miscellaneous receipts in both the General and Education Accounts.

4/ Excludes borrowing for projects in the self-financing project category.

large increases since 1967. These expenditure increases must be financed from some combination of (a) increased tax revenues, (b) increased non-tax revenues, (c) increased external assistance, (d) increased short and long-term borrowing, and (e) increased revenues from "self-financed" projects which generate revenues that cover some part of costs. There are wide year-to-year variations in the importance of these various sources of finance; generally, the contribution of self-financed activities has been large and growing.

Tax revenues have amounted to about 30 percent of total expenditure over the period; they have increased in line with total revenue and maintained their share in it (see Table 2). Tax revenue increases may result from either changes in the tax rates or structure, or from automatic growth due to the income elasticity of the tax structure; in Seoul, the expenditure increase financed by taxation was almost entirely due to the latter. "Self-financed project revenues" are the major source of finance for the expenditure increase. However, the figures for this category in Table 2 are larger than the values for project-generated (i. e. self-financed) income since long-term borrowing for these projects is included in this amount, as are also some general fund transfers. A more complete picture may be gained from Table 2 in conjunction with the breakdown of self-financed project revenues presented in Table 3.

General non-tax revenues, e. g. fees, permits, licenses, etc., have declined in importance as a source of financing expenditure increase over the period since 1965. This is largely due to the low level of these charges and a structure of charges that does not respond proportionately to income increases. External assistance has likewise dropped as a percentage of total financing, primarily because of revisions in central government grant/subsidy distribution formulae. The proportion of expenditures financed from external grants in aid fell from 19. 8 to 15. 8 percent over the 1964-1971 period.

Some Self-Financing Activities

The remainder of this article will describe some of the "self-financing" activities as organized by the SSC. They are not, of course, financed without any assistances from the SSC through transfers from general funds, or transfers from the national government. Nevertheless, the extent to which self-financing has been achieved in the rapid expansion of infrastructure and services for this large and fast growing city, and the ways in which this has been done, are of particular interest as examples of urban finance in a developing country. Project-generated revenues include user charges of various kinds, and proceeds from the sale of assets. Some activities can be wholly financed from such sources, while others are only partly self-supporting.

Table 3: Components of Self-Financed Project Revenues, 1968-72
(In Millions of Won)

	1972	1971	1970	1969	1968
Total Revenue	19,592 (100.0)[1]	20,334 (100.0)	15,082 (100.0)	12,787 (100.0)	8,341 (100.0)
Transfer from General Account	2,425 (12.4)	788 (3.9)	388 (2.5)	4,161 (32.5)	1,577 (18.9)
Borrowing	5,363[2] (27.4)	4,500 (22.2)	— —	100 (0.8)	803 (9.6)
User Charges	1,152 (5.9)	1,357 (6.7)	1,150 (7.6)	1,040 (8.1)	1,067 (12.8)
Sale of Assets	5,312 (27.1)	5,601 (27.7)	6,842 (45.4)	5,303 (41.5)	2,629 (31.5)
Other	5,340 (27.3)	7,909 (39.4)	6,703 (44.4)	2,184 (17.1)	2,265 (27.2)

[1] Figures in parentheses are percentages of total project revenues.

[2] Includes 3,676 million won borrowed from external sources.

SOURCE: Financial data for Special Accounts compiled by Seoul officials.

Note: Total revenues shown here differ from those for self-financed projects in Table 2 due to exclusion of revenues from night soil collection and pawn shops.

Water supply. The supply of drinking water for the Seoul metropolitan area is drawn predominantly from the Han River and is treated to acceptable standards of purity in treatment plants at five locations. The water produced is then distributed to about 86 percent of the city's total population, or 90 percent of the population within the present service area. The service area includes all parts of the city except some low-density fringe areas at elevations of 100 to 120 meters. Water loss, that is, the difference between treated water produced and water recorded on customer meters, is high; it is attributable mainly to leakage from old pipework, under-recording by meters, and illegal connections. Loss due to "accepted" unmetered usage, such as fire-fighting and certain civic functions, appears to be normal. The Water Bureau, by devoting considerable effort and expenditure to loss correction, reduced loss from an exceptionally high 62 percent in 1960 to 44.5 percent in 1970.

The Water Bureau was established to operate as a self-supporting entity, dependent primarily upon resources derived from the sale of water. The SSC Water Bureau has consistently generated a surplus on its current account and, accordingly, has financed both debt repayment and a portion of capital expenditures. The remainder of capital expenditures is chiefly financed through domestic and foreign borrowing for specific capital projects. There has been some transfer of resources from the city general account in a few years to meet a portion of the capital spending, but these amounts have been relatively small (only in 1969 was it as much as 5 percent of expenditures). Hence the water supply function is basically self-sufficient.

This self-sufficiency is a result of substantial revenue growth, which in turn may be attributed to increasing water consumption and to discretionary increases in water rates. There have been only three changes in the rate structure over the past decade: in 1968 and 1970 the city raised its water charges for industrial and commercial uses, and in 1972 residential rates were approximately doubled.

Land adjustment. The SSC has a land adjustment scheme, so called, under which certain areas of the city are designated for improvement. The improvement consists of rearranging the shape of plots, land grading, laying out and constructing roads, and provision of other basic infrastructure. The objectives of the program are: (a) to facilitate the development of areas, usually on the city's urban fringe, and usually difficult to develop because of their physical characteristics (plot shape, size, or topography); and (b) to recover public sector costs from such development. Fiscal transactions under this scheme are made through a Land Adjustment Special Account and administered by the Land Adjustment Bureau of the SSC government. The Land Adjustment Bureau has no maintenance responsibilities after the development takes place.

The city administration has a five-year plan with respect to areas designated for land adjustment. The decisions on which lands are to be adjusted are made by the Mayor and the city administration; it is also required that a majority of land owners agree to the projects. The finances of the land adjustment program are kept entirely in the Special Account, with the fiscal resources for the program derived from borrowing and the resale of land. The landholders must surrender some of their land to the government as payment for the improvements they receive. The landowner whose land will be improved donates to the government an amount of the land adequate to meet the costs of the improvement plus an amount for general uses such as parks, and open spaces. The government then resells the land to recoup the cost of improving the land. As of October 1972 there were 38 land adjustment schemes undertaken, 27 of which are complete; and the expenditure for the adjustment of land amounted to about 40 billion won.

Land adjustments can be initiated either by decree of the Minister of Construction or by those who are connected with the lands which are being adjusted, for example the city government, the National Housing Corporation, or a land-owner association which is formed for that purpose. The land adjuster, public or private, must submit an application to and obtain formal permission from the Ministry of Construction. The land adjuster first designates a certain area for land adjustment. Next, the land adjustment scheme is announced to the public and remains open to those concerned for public reference for a period of 14 days. The proposed scheme, the method of covering costs, and other matters must be approved by at least two-thirds of the land-owners. If the land-owners approve, the land adjuster then submits the land adjustment scheme to the Ministry of Construction and procures a permit. The land adjuster, most often the Seoul City Government, undertakes the planning and execution of the scheme.

Eventually all the costs of land adjustment are borne by the land-owners in the adjusted area. A precise description of the allocation of these costs among land-owners is beyond the scope of this article, but a general description might give some indication of the process. The land to be improved is classified into one of three categories, A, B, or C, according to the ease with which it can be adjusted, class A land being the easiest and least costly to adjust, and class C land being the most difficult. Cost estimates for these categories are based on past experience, and are obtained after detailing the cost of all improvements, e. g. fill, lands, sewerage, and drainage. The estimation of the selling prices for these types of land is also based on past experience. The area of the land which, if sold, is enough to recoup the cost of land adjustment is then calculated. The land adjuster sells the appropriate amount of land to private or public buyers and recovers the total cost of improving the land.

In addition to this "cost equivalent" amount of land, some common rate of land is surrendered by all land-owners to allow land for public parks, public squares, open spaces, and other public uses such as markets and schools. A proportion of 25-35 percent has been mentioned as being commonly required for institutional use. Finally there is an additional amount of land which must be surrendered for roads. The amount of land surrendered by an owner differs according to whether the road is in the front or beside his property. For front roads more than 10 meters wide and side roads of any width, the amount of land surrendered on either side of the road does not add to the total width of the road. The remainder is contributed by all owners on an equal rate basis. If there is a discrepancy between the actual cost of the adjustment project and the revenue from sales of cost equivalent land, then the difference will either be returned to the land-owner or invested in further improvement of the area. It is, however, rare that the price of the land after improvement is overestimated. These land adjustment activities have been a major factor in the in-

crease in SSC expenditures. The Land Adjustment Special Account has shown consistent annual surpluses from 1963 to 1972, with loan repayment more than covered by income from resale of lands.

Han River Project. Although the Han River Project is a form of land adjustment, it is treated as a separate Special Account. The purpose of the project, which started in 1968 and ended in 1972, was to construct several toll roads around the Han River connecting the city of Seoul with Yoido Island, which is located in the middle of the Han River and was granted by the Central Government to Seoul Special City. The project was also designed to develop Yoido Island, and included the construction of a protective dam around the island, filling and levelling ground, construction of roads, a public square and the provision of public utilities. The area of the island is about 2.8 km^2, of which 60 percent was developed for commercial use and 40 percent for housing. Most of the cost of the Yoido development was covered by sales of the improved land to the private sector and to other special accounts of Seoul City, such as Housing. Only 13 percent in the way of general account subsidy has been necessary in the overall financing of the Han River Project, almost all of that coming in the first year to enable start of construction.

Roads and bridges. The responsibility for planning, constructing and maintaining all roads within the Seoul urban area is divided between the SSC government, the central government, and the Korea Highway Authority. The city government operates two toll roads and several toll tunnels. The fiscal operations for these including debt service on loans is budgeted within the city's special account for the purpose. By 1973, budgeted toll road receipts were more than adequate to cover expenses associated with the maintenance and improvement of these toll roads. SSC expenses for all other roads and bridges, however, are shown in the general revenues.

Transportation. The transportation function in Seoul is defined to include traffic control, a minor and stable expense, along with the capital and current support of mass transit facilities. Until 1971, the bus system was the only form of mass transit included in the budget; subway construction first appears in the 1971 budget. Both bus service and subway construction are Special Account items, and together they account for almost all of the increase in transportation expenditures over the past decade.

The city bus company, which began operations in 1965, operates throughout the SSC and beyond the city limits. Bus routes are recommended by the city administration, and decided by the Mayor. Operational policy is that fares should at least cover current (operating and maintenance) costs. Bus company expenditures have doubled from 1968 to 1972, with the increase about evenly divided between current and capital expenditures. The financial sufficiency of the bus operation has weakened over this period, and the amount of transfer from the city general budget has increased. Bus fare revenues generated a sizeable surplus over current costs in 1968; but this became a modest deficit after 1969, and

extra-account funds have been used to cover all capital expenditures. Thus, despite recent increases in bus fares, self-financing of capital expansion is still out of reach, though current deficits are not large.

Housing. Both the city government and the national government are involved in public housing in the Seoul urban area. The SSC government's housing activities include housing construction for rental, housing construction for sale, and the rehabilitation of low-income housing. The rental program stems from city government apartment construction for slum dwellers. During the 1962-67 period, five pilot projects, including 240 housing units, were constructed, of which the city retains ownership. In at least three schemes, the SSC government constructs and then sells houses. First, under slum renewal during 1969-71, there was a total investment of 6.3 billion won in 430 "citizens' apartment buildings" with 22,000 units, constructed on cleared squatter areas. A second program, primarily for middle-income people, was begun in 1970 with financing through mortgage banks. The third purchase scheme is a special apartment complex on Yoido Island.

The city government is also involved in the rehabilitation of low-income housing. Under this program, squatters on government-owned land are given a chance to build according to prescribed standards. If they fail to do so after a certain time, they are evicted; if they meet acceptable standards, they are granted title to their dwellings. Finally the city government is involved in urban resettlement. This includes the Kwan-Ju urban development project and small settlement projects in approximately 43 locations around the city. The city has spent about 16 billion won on these developments, which are planned for about 36,000 households. The occupiers are obligated to pay the total cost of development in 10 annual installments, with no interest.

Expenditures on citizens' apartments, rehabilitation, and resettlement averaged about 4 billion won per year in 1969-72, over 95 percent of which is capital costs. Loans for higher level schemes, including both apartments and detached housing units were between 500 and 700 million won per year: debt repayment constitutes less than 2 percent of the total expenditure. There was a sizeable subsidy from city general revenues to support the housing program in 1969, but in other years the contributions of the central government have been by far the largest source of revenue. Thus, the program is almost entirely dependent on outside assistance for its capital expenditures. To some extent current costs are financed through tenant payments: for the loan amount, the city government borrows from a bank; the tenant pays a monthly rental, which the city government uses to amortize the bank loan until the debt is fully repaid; ownership then passes to the tenant.

Education. Primary and secondary education in Korea is a local government function. Current expenditures have been roughly two thirds and capital one third of the total for education, which is the

largest item in the SSC's budget. Education revenues are derived from three main sources: tuition, a contribution from the SSC government general account, and external assistance. Of the three, tuition and the general account transfer together account for about 40 percent of total receipts, with central government assistance accounting for the remaining 60 percent. Revenues from tuition fees, paid by junior and senior high school (but not primary school) students, have grown markedly in recent years with increasing enrollments. The fees have paid for an increasing share of education spending, rising from 11.2% in 1968 to 20.1% in 1971.

Conclusions

The demonstrated ability of the SSC to increase infrastructure and services to its fast growing population in 1963-72 is unusual among developing-country cities. This result was assisted by a rapid rate of economic growth in Seoul, and in South Korea, in these years; but success cannot be attributed to affluence, since the per capita income level is still relatively low. More important were the methods of organization and in particular the search for self-financing devices such as those which made the water works, the land development programs and the Han River development virtually self-supporting. To be sure, the self-financing revenues in transportation, housing and education have been much more limited, though perhaps more extensive than in other cities. But there seems little doubt that project-generated revenues made possible some capital projects that would not otherwise have been undertaken, and freed some revenue for other uses that might otherwise have had to go into those capital projects that were deemed essential.

Infrastructure building aside, the SSC also has a good record of keeping up with the more routine services under pressure of growth. Some estimates of the elasticity of response to increases in SSC income are the following:

Increase in total tax revenue	1.15
Increase in locally raised non-tax revenue	.96
Increase in General Account expenditures	1.01

These figures indicate that tax revenues have grown somewhat faster than income levels, while general administrative costs and local non-tax revenues have more or less kept pace with income. As noted earlier, reliance on central government grants and on non-project borrowing has decreased. Thus, even if the self-financing projects in the budget are not considered, SSC finances are evidently both sustainable and flexible in response to need.

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Financing Urbanization by Benefit Taxation

William G. Rhoads and Richard M. Bird

[The financing of capital improvements in fast growing cities has become increasingly difficult. This article analyzes in theory and in practice (in Colombia) a valorization tax designed to raise capital from real estate owners who benefit from improvements, a method which merits serious consideration in fast-growing cities of industrializing countries.]

A striking phenomenon in the developing countries today is the rapid growth and urbanization of their population. This rapid urbanization has put tremendous strain on municipal finances. Heavy investments in roads, sewers, aqueducts, street lighting, parks, and schools seem needed if the city is to remain suitable for human existence, but there is no capital market from which funds can be borrowed and the national governments cannot provide adequate assistance to finance capital investments. Even though forced to rely on their own resources the city should theoretically be able to raise considerable revenue from orthodox property taxes. In practice, however, we know of no developing countries where the property tax has been exploited to anywhere near its potential capacity to provide municipal revenues.

Despite the failure of the property tax in Colombia to respond to urban needs in recent years, some Colombian cities have developed an alternative tax on real

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property which has made a significant contribution to financing urban capital improvements and which will be discussed here. This tax is known as the "impuesto de valorización" or valorization tax. It is similar to the taxes known as special assessments or betterment taxes in English-speaking countries. This type of tax, which by its nature can be used only to finance capital improvement, was formerly much used in the United States and in other developed countries, but has since fallen into disuse and has been almost totally ignored in recent public finance literature. However, the valorization tax is more appropriate for developing than developed countries, and as used in Colombia the tax is also free of some of the defects that led to its downfall in the United States.

The Problem

In developing countries cities typically grow very rapidly. In Colombia the average rate of urban growth is 5 percent a year and the three major cities — Bogotá, Medellín, and Cali — grew in the last decade at average annual rates of 7.7, 6.2, and 7.5 percent respectively. The rapid growth of these cities arises both from their development of dynamic manufacturing and commercial sectors and from the increasing importance of education, health, and other activities which are most efficiently carried on in urban areas.

City growth in developing countries today is usually based on transport by urban buses. For efficient transportation, the narrow streets of the central city — in Latin America a heritage from colonial days — must therefore be widened and new streets opened. On the edge of the growing city, streets must be extended rapidly to new factories and new housing, often single-family homes being developed slowly from original squatter settlements by owners lacking the organization, financing, and technical capacities to build more compact multi-family structures even if they wanted to do so. If the city is to be a location of low-cost production, it needs these streets to provide rapid bus transportation. It also needs adequate water and sewerage systems to protect public health, and street lighting, parks, and schools for training and social betterment. All these investments require large amounts of capital, and yet they must be provided if the city is to fulfill its potential for economic development. This investment is desirable not only for the benefits which it gives in better living conditions and more efficient production in the city, but also because it requires a great deal of unskilled labor, thus helping to ease the always heavy urban unemployment in developing countries. Such public works investment generally uses few imported materials and so puts less pressure on the balance of payments than most other types of investment.

There is usually no organized capital market where domestic funds can be borrowed for long periods at low interest rates to meet these

heavy capital requirements. Some improvements might be financed by borrowing from international lending agencies; but these agencies are usually reluctant to finance local currency costs of investments and, as was noted, import requirements for these urban investments are low. Some investment funds may be provided from central government subsidies but these are likely to be inadequate, given the usual fiscal difficulties of the central government in a developing country. Nor can the city rely heavily on the ordinary local property tax: property assessments are usually out of date and inequitable, and the administration and collection mechanisms are weak, while legal mechanisms to enforce payment are lacking. Finally, the city usually cannot call on private enterprise to finance these investments through subdivision laws which require the urban developer to provide streets, water, sewerage, etc., at his own expense. Even if such subdivision laws exist (as they in fact do in Colombia) many people purchasing lots simply do not have the money to pay for complete public improvements, so the subdivision law would only bring legalized housing growth to a halt if it was enforced — with a consequent increase in illegal shanty towns.

A Partial Solution

The same factors that lead to the financial difficulties of the rapidly growing city in a developing country — the large influx of population and the rapid growth of modern industrial, commercial, and service sectors — also lead to a rapid rise in property values. This fact can be used to advantage to finance a major part of the needed municipal investment through taxing this increase in value.

The rapidly growing city in a developing country always has many potential projects with such a high social productivity that the benefits to site values greatly exceed the costs of the project itself. In theory the valorization tax could recover an amount equal to the entire increase in site values; in practice, something less than this should be attempted, given the desirability of securing payment of the tax before the investment is completed and the uncertainties of estimating what the ultimate increases in site value will be. Even allowing an ample margin for error in estimating benefits, however, the tax can usually recover the investment and operating costs of the public agency without exceeding the realizable benefit to any individual landowner from the increased site value of his property. This presumption of increased value in the law — a major reason for the distrust of the textbook writers — has in fact worked out quite well in Colombia for reasons outlined briefly below.

Theoretical Appraisal of the Valorization Tax

A valorization tax may be contrasted with a traditional property

tax assessed on site value, and with special capital gains taxes on increases in site value. In theory a property tax assessed on site values can collect the entire net rent of the land. A capital gains tax on increments in site value can recover the total increment in site value, but payment usually takes place only after the increment in value is realized by sale. The practical difficulties of taxing unrealized gains on an accrual basis are well known. Another difference between site value taxation and valorization taxation is that, in theory, the valorization tax recovers only the benefits from direct public investment which enhances the value of land, while site value taxation also reaches increases in private site values that may arise in a large, heavily-populated urban area from external economies. Neither the site value tax nor the gains tax on increment in site value is designed to raise the revenues to provide the public investments which will lead to an increment in site value, but if a capital market existed, they could be used to repay loans made to finance these public investments.

The valorization tax has the political advantage that it is clearly on a benefit basis. The taxpayer is making no sacrifice, for the value of his property will rise by at least the amount of the tax he must pay. This is an important consideration where political resistance to paying taxes is high, as it is in most developing countries. In practice, since the tax is paid before the investment takes place and before site values increase, the estimates of the increase in value must be sufficiently accurate, or the upward trend of land values because of urban growth must be so rapid, that the forecast of benefit exceeding tax will be true in almost all cases. In effect, the increment in site value from rapid urban growth and inflation provides a cushion in case the increment arising from the public investment alone turns out to be inferior to the valorization tax paid.

From urban land use and transportation theory it may be predicted that a valorization tax, justified as it is on a benefit basis, will be most successful if the urban area is growing rapidly. The main use of valorization taxes has been to provide new or improved streets in urban areas, an investment needed to keep production costs low in urban areas with existing transportation technology. Theoretical analyses of improved urban transportation providing more rapid access to the central business area show that ordinarily site values in the fringe areas of the city with improved transport will increase and, ceteris paribus, site values in the central areas and other fringe areas will fall. If benefit taxation is to be successful there must be an obvious connection between the cost and the benefits to the taxpayer. In a static or slow-growing city, suburban and fringe urban dwellers will not be convinced that the increases in their site values are coming from improved roads located in the older central portions of the city. However, if increased transportation efficiency lowers production costs sufficiently in the city to attract new industry and economic activity to cen-

tral areas at a rapid pace and urban population increases rapidly, urban land values in central areas will also rise and central city land owners will be willing to pay valorization taxes. The relationship between public investment and site values may be indirect, but the property owner will know from experience that better streets in front of or near his property will increase the value of his land. The neglect of the valorization tax in public finance literature and in developed country practice may be accounted for in part by the slower growth of cities in developed countries, with consequently less connection visible between public improvements and increases in site values. Other factors explaining the lesser usefulness of the valorization tax in advanced countries are the existence of capital markets, so that public improvements may be easily financed and paid for out of regular revenues over time, and the existence of subdivision laws which force many public improvements to be made at private expense.

From the point of view of stimulating saving and investment, the valorization tax also seems desirable in developing countries. The proceeds of the tax are used almost exclusively for investment, and the nature of the tax is such that if it is to be successfully used, the investment must be highly productive in order to increase land values. In fact, the valorization tax may be considered a forced investment, where the taxpayer benefits from the increased site value of his land resulting from the public improvement financed by the tax. Income distribution in developing countries is highly unequal and much urban land is owned by the wealthy upper classes. While these groups could be major sources of saving, they often consume a surprisingly large fraction of their income; thus, the valorization tax often falls heavily on a group which has the potential to increase its savings considerably, and might well do so to pay the tax.

The incentive effects of the valorization tax are also favorable to investment and development. It is often stated that in theory a tax on site values should have no incentive effects on land use since it does not affect the most profitable use of the land. This statement, however, implicitly assumes that land is always an investment good. In fact, in developing countries much land is held idle not for speculative purposes but to provide pleasure and prestige to its owners so that it is in a real sense very often a consumer good. Under regular site value taxation, the income effect of taxation can be expected to lower such consumption, so that land used for consumption purposes may be put to productive use as a result of the tax. With the valorization tax the analysis is different, for payment of the tax is matched by an increase in the site value of the land. The improvements financed by valorization taxes increase the value of the land for productive purposes, however, not for prestige consumption, so the tax and public investment combined will increase the opportunity cost of using land for consumption purposes.

In practice, the effect of site value taxes in forcing more intensive land use may depend mostly on the lack of liquidity and capital markets facing many landowners, and on the common failure of landowners to calculate carefully the most profitable use of their land. Owners may under-utilize land when not faced with cash payments; but when the valorization tax must be paid, they may either realize the opportunity cost of holding the land idle and hence put it to more profitable use, or else they may have to sell it to someone else who will do so. Since the valorization tax is a relatively large tax assessed over a short period of time, its effect in forcing better land use through the liquidity and attention-to-use effects should be stronger than that of a regular site value tax, where the rate may be too low to threaten the liquidity or arouse the interest in land use of all but the largest landowners.

From an administrative point of view the valorization tax may seem attractive to developing countries, for land cannot easily be hidden from taxation. The tax is collected in large sums from a relatively small number of taxpayers, a fact which makes enforcement easier though it may make compliance more difficult. The crucial factor in administration is that the tax and the public improvements go hand in hand. Poor administration will lead to badly-planned projects or to projects which are not executed promptly, or to poor allocation of taxes among landowners so that a significant number of taxpayers will find that the tax they pay is larger than the increase in the value of their property. Without skilled administration the tax may easily become discredited and appear to be only an arbitrary and capricious capital levy.

The Valorization Tax In Colombia

The present valorization tax in Colombia was developed largely in the city of Medellín over the last twenty years, primarily as an indigenous response to the need for financing municipal improvements in a fast-growing manufacturing city. Under Colombian law, municipalities have complete autonomy in valorization tax administration. In Medellín, a separate municipal department handles all aspects of this tax from preliminary study of projects through design, financing, and contracting the public works to the collection of the tax. The valorization department has in recent years provided Medellín with a large and impressive network of parkways, limited access highways, improved river and stream channels, parks, and other improvements.

Although autonomous, the department is of course responsive to pressures from taxpayers and other political forces and is careful to maintain popular support for its work. Projects are studied carefully to select only those that will produce benefits to property owners

greater than their cost. When a project is selected the cost of the project plus the administrative cost of the agency is charged to the taxpayers in the area benefited. In selecting the area over which the tax will be assessed for a project and the relative charges to be levied on each property, the valorization department does not rely at all on formulas (as is done in Mexico, for example). Instead, it consults with real estate dealers and other knowledgeable persons to work out a consensus which appears plausible to all on the distribution of the benefits from the project. Despite the theoretical difficulties in determining site values and calculating increases in site values as a result of public improvements, the Medellín consensus system is reported to work well; for most projects it has not been difficult to reach agreement on the tax to be charged on each property. The valorization tax is payable either before the start of the project or, at the taxpayer's option, in installments over a period of two years or so. This method requires the use of some short-term bank loans or bond financing to carry out projects. Various methods of discounts for cash payment, interest rates on installment balances, and premiums for valorization bonds previously purchased are used in an attempt to limit the short-term financing required from the banks.

The valorization tax in Medellín in recent years has produced more revenue than the regular property tax, and has contributed about 30 percent of the total current revenues of the city government. In Bogotá, a larger, more complex, and less homogenous city, the valorization tax has also been used extensively. The system used is generally the same as that developed in Medellín. However, because of somewhat greater political interference in the valorization process and because of noticeably less competent management in the past of the processes of financing and constructing improvements, the tax has been less important in Bogotá. Still, the tax cannot be called a failure for it has been used extensively, enjoys good support, and the prospects are for greater use in the future. In Bogotá the valorization tax has provided about half as much revenue as the regular property tax and contributes about 25 percent of the city's total tax revenue.

In Cali, the third largest city, the valorization tax has been used very little. The principal reason for this state of affairs is political opposition from large property owners. Similar opposition was also a problem some twenty years ago in Medellín; but it was overcome after an epic struggle when property owners finally recognized that if they wanted improvements which benefited their properties they would have to pay for them out of valorization taxes, and abandoned the hope of getting improvements financed out of taxes paid mostly by others. The process of political education has not yet progressed this far in Cali.

A comparison of revenues for Medellín, Bogotá, and Cali indicates that the valorization tax has not replaced other municipal taxes. On a per capita basis Medellín has both higher property tax revenues and higher total taxes also than the two other cities. Although further study is needed to clarify the relation between use of the valorization tax and use of other sources of revenue, the indications are that in Colombia the valorization tax has not had an adverse effect on other taxes.

Some Practical Lessons From Colombian Experience

(1) Taxing on the basis of benefit. The valorization tax appears to have been most successful in Colombia where the greatest efforts have been made to put it on a true benefit basis, as in Medellín. To do this seems to require the following elements: (a) freedom from any fixed formulas for distributing the tax among property owners; (b) careful study of projects at the initial stage to determine those which will truly bring increased site values equal at least to the cost of the project; (c) participation of property owners in the planning and execution of projects wihtout obstructionist or veto powers; (d) careful costing of projects; (e) prompt construction of projects; (f) prompt and complete collection of all taxes assessed while the project is being built; (g) extensive publicity of valorization projects; (h) a general statement of the rules for hardship cases permitting, but not requiring, reduction in tax or delayed payment in certain circumstances. The development of a valorization system is also a matter for careful planning. Medellín's experience indicates the importance of starting with small projects which can be completed quickly and with certainty and thus earn taxpayer trust. At a later stage it might be better to concentrate on large multi-faceted projects.

While there are no empirical studies available to show how closely valorization tax assessments have corresponded to subsequent increases in site value in Medellín, there is a general feeling by officials and other observers that the tax has been on a basis proportional to benefits. Preserving a popular identification between the tax and the benefits by all possible means is repeatedly emphasized in Medellín.

(2) Exemptions. There is little reason for exempting any property from the valorization tax. The exemptions of government property, common in Colombia, have given windfalls to such private-interest public groups as military pension funds. Failure of government bodies to pay assessments has seriously hurt the financial soundness of valorization in Bogotá. Exemption may be justified for small landowners who are illiquid and cannot raise the cash to pay the tax assessed; but this problem can usually be solved in practice by giving small landowners longer periods to pay, and by making special arrangements in hardship cases.

(3) Earmarking of Revenues. Public finance textbooks tend to condemn earmarked revenues because they limit the flexibility of budgeting in a government, glutting some activities with too much revenue while others starve. This can only be avoided if the rate of the earmarked tax is changed regularly to bring it in line with actual revenue needs. This is the case with the valorization tax. Further, the financing of investments from the earmarked valorization tax gives an added incentive to examine the prospective benefits of projects more closely than would otherwise be done, and hence promotes good budgeting and project appraisal procedures.

Benefit taxation may be made politically popular. However, critics may then charge that those activities which can clearly be financed on a benefit basis receive too much support at the expense of other activities which for technical reasons cannot be benefit-financed. The force of these charges is lessened to the extent that benefit taxes can be shown to be an addition to other taxes, expanding the size of the public sector rather than substituting for other more general taxes.

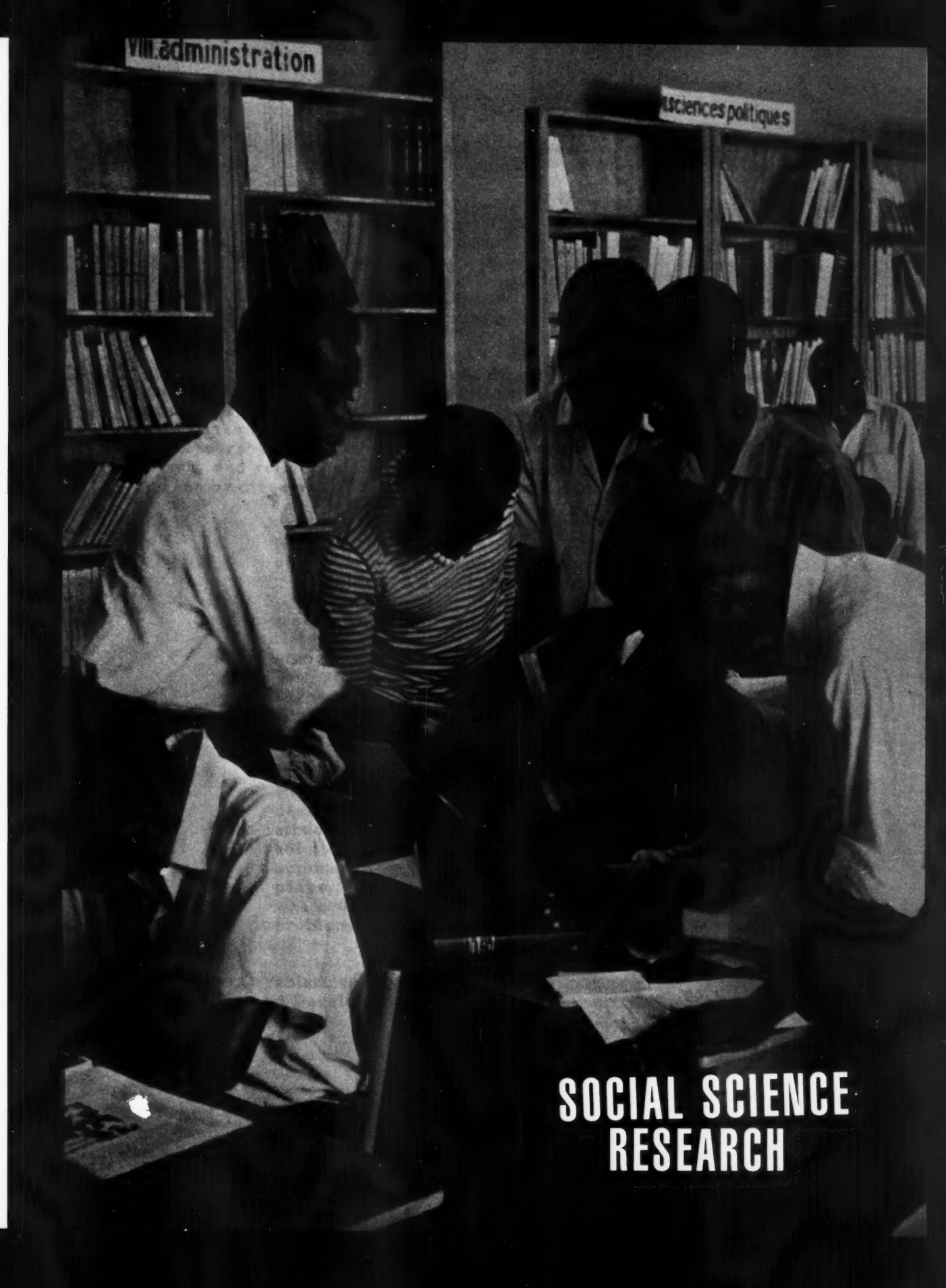
(4) Relation to other taxes on property. The valorization tax is compatible with a capital gains tax on increments in site values provided the valorization tax is included in the original cost of the property when calculating capital gains,as is done in practice in Colombia. Assuming that the valorization tax and the capital gains tax together recoup for the public sector the full increment in land values, it may seem unfair to also have a regular property tax. But public improvements have maintenance expenditures, and the cost of maintenance should be paid by those who benefit. Also, it will rarely be the case that all increments in land value can be taxed away by the valorization and capital gains tax. Finally, it must be recognized that most property taxes go to finance municipal services for people who live in and use buildings and other site improvements, and if taxes are to be benefit-based much of the property tax should be on improvements.

(5) Effects on income distribution. In terms of the usual definition the valorization tax is probably a progressive tax since it is related to property, and property ownership is more unequally distributed than income in almost all countries. Compared with probable alternative ways of financing public improvements, the valorization tax probably favors the poor over the wealthy and yields a more equal income distribution. This presumption is somewhat confirmed by the fact that the strongest opposition to valorization taxes in Colombia has come from some of the wealthier groups in the country who own much of the urban land.

Conclusion. The valorization tax as it exists in Colombia, particularly in Medellín, seems to have a useful but limited role to play in economic development. It is effective in financing certain special-

ized types of public investment at a certain stage in the economic development of a country. For the tax to be useful the country must have reached a stage where urbanization is proceeding at a rapid rate and large modern cities are being formed. The country must also have developed capable administrators, real estate men, and engineers who can handle the complicated machinery of the valorization tax. City planning must also have become feasible. Yet the country must not have yet reached the stage where capital markets have developed which can take over the job from the valorization tax, or where the city has become so large and intricate that the relation between public investment and increases in site value is too complex for valorization financing to work. There are many other countries in the stage of development Colombia is now in, or soon to be there, and Colombia's experience may be of interest and use to them. At present there is great interest in Colombia in extending the valorization system to new uses and increasing its importance in current uses. Colombians feel that the experience in Medellín and elsewhere in the last twenty years has established both the general principles and the specialized methods needed for successful valorization programs.

[Extracted from Chapter 35 of Readings On Taxation in Developing Countries, Richard M. Bird and Oliver Oldman, Editors, pp. 453-463. Published by The Johns Hopkins University Press. Baltimore, Maryland, 3rd edition 1975. Copyright © for this article: The University of Wisconsin Systems.]



SOCIAL SCIENCE RESEARCH

STUDENTS AT A NATIONAL RESEARCH
INSTITUTE IN ZAIRE
(PHOTO: UNITED NATIONS)

Issues in Development Research Cooperation

OECD

[A major international conference of directors of 108 research and training institutions of developing and industrial countries and international organizations was held in Abidjan in August, 1974 to discuss new forms of collaboration among them. This article is based on the rapporteurs' account of the discussions in the Working Group on Research, and reflects a wide range of purposes and current problems as seen by directors of research institutes around the world.]

Reasons for and Needs of Research Cooperation

Discussion under this general heading started from a general recognition of participants that social scientists around the world were basically united. They all strove in the pursuit of knowledge, they all desired policy relevance of their work, and they were all concerned with improving the living conditions of people. It was felt that this common ground was perhaps more important than the distinction between problems in developed and in developing countries. Their common problems nevertheless appeared in different forms. Previously, the differences between developed and developing countries had had to be emphasized very strongly, mostly to caution decision-makers that solutions copied from developed countries would not automatically work in the developing countries. This phase, however, now appeared to be over, and there was good reason to emphasize the similarity of many problems in all parts of the world.

OECD: the Organization for Economic Cooperation and Development, Paris, France.

There were reasons why cooperation between the developed and developing countries could be useful. It was agreed by some participants that foreigners might be in a position to secure better cooperation from government authorities since they were not suspect of pursuing domestic politics. An alternative to having developed country researchers come in for this reason could well be to organize cooperative research activities with other nations within a region. The reverse side of the medal for any foreigners was of course that they would have less understanding of ideological requirements in a given developing country, or acquaintance with the real needs felt by its population.

The first and very important area of cooperation that the meeting agreed upon was the need for the exchange of information in general, and scientific exchange in particular. This exchange was essential in both directions and would be necessary even in a situation of dominance by the developed country partner, since without it the developing countries could not adjust their research designs adequately.

A second area given great attention was that of institution-building. It was felt that independent research institutes in the developing countries were an essential requirement. Helping to build these institutions was in the interest of developed country institutes because, in the longer run, the LDC (less developed countries) governments would certainly be forced to use local institutions in preference to foreign institutions. There may well be three stages through which an LDC institute should go with respect to cooperation with institutes from abroad:

a) In the initial phase, the institution should be financed entirely with local money, should do its own local research work, and should neither solicit nor accept outside financial or intellectual inputs.

b) Once it had found its own style, it could then accept some outside help but mostly in terms of material help, i. e. equipment, library facilities, etc. Priority setting should still remain a national responsibility.

c) It is only when the institution had matured to the level of equality with foreign partners that joint financing of research projects should become possible and a dialogue might be engaged with the foreign partner as to the type of research to be undertaken.

It was suggested that the scope for cooperative research was particularly large in common global questions: examples were multinationals, communications, systems of political power, education, etc. It was in this area that comparative research might have the best pay-off and therefore be undertaken in partnership. True partnership involved, of course, not only DC researchers going to LDCs but also the reverse, so that people from developing countries could get better acquainted with

the problems of developed countries and make their own contribution to developed country problem solving.

Possible Areas of Conflict

A point that was made strongly by the African participants was that researchers from developed countries should accept work in Africa for long periods, not only for short spells. It was recognized that this might create conflicts with the institutions they came from; in particular, it disrupted the working of a university if senior staff were absent for lengthy periods. However, the meeting also heard a statement from a representative of one U. S. university whose institution had, after due reflection, deliberately decided to release staff for lengthy periods: they felt that a lengthy stay was required for a proper understanding of the recipient country's problems, and that the disruption caused was more than compensated by the contribution the person could make to the university life upon return.

Another point given some attention was that often the personnel from developed countries sent into developing countries for cooperative purposes were less qualified than the staff in the recipient country. This was very strongly criticized. Repeatedly, an appeal was made for modesty on both sides. Developed country experts should refrain from trying to impose their own models on the developing country, and researchers in the developing countries should recognize that their foreign partners might have something significant to contribute.

It was suggested that conflicts can arise on at least two levels. First, they may well arise between the research partners in setting priorities. For example, a developing country institution might not be entirely free to set its own priorities; there might also be political constraints on collaborating with foreigners since the LDC government might not approve either of the subject or of the fact of collaboration, or of the collaborator. The second area was potential conflict between a research project and the users of its results. This was particularly possible when developed country researchers came to do research for use by their own policy-making authorities, and where this research might not correspond to the views or needs of the recipient country. It was therefore felt that collaboration had the best chances if priorities between the partners were in agreement.

Setting Priorities and Planning Research

The meeting heard all shades of opinion on this issue, ranging from total freedom for the researcher to choose his subject of work to strict planning of all research activities in the social and the economic field. The largest body of opinion fell between these two: it

was generally recognized that total freedom in choosing research subjects was somewhat inconsistent with the need of research to be relevant to policy issues, while total planning of research had the danger of being time-bound and unable to foresee the real longer-term problems.

Two consequences flow from these considerations. The first is that, if total freedom is rejected, then the developing countries must develop the capability for setting research priorities. It was argued that these priorities should be set by the LDCs themselves; the developed countries should come in on the understanding that they accept these priorities. However, the view was also expressed that this could be exaggerated, and that it would be ideal if priorities could be set in dialogue with the research partners; however, developed country experts should be discouraged from applying their ideologies and give more room to "free thinking." Secondly, it was felt that we should not give up the support to research whose relevance and priority was questionable, as overall strict planning of research would probably do: we had to recognize that research was indeed a very high risk activity, and one could not a priori tell what the pay-off would be. In the same vein, research should attempt to stay free of fashions which beset development thinking, like many other human activities, but were really a deterrent to solid and useful work. To sum up, it was suggested that researchers should be daring in the choice of subjects but humble in promoting the immediate application of their results. Such modesty should be paralleled by making greater use of practitioners, and promoting many more empirical studies: it was indeed felt that development practitioners had a great deal of data and insight to contribute to research per se.

Finally, a suggestion was made that it might be useful to look into the setting up of a consultative group on research in social and economic development, somewhat on the lines of the consultative group formed under the auspices of the World Bank for agronomic research.

Relevance and Policy Orientation of Research

While the Directors of research institutes could not be expected to deprecate the relevance of social science research to development problems, it was pointed out that the financers of research were not necessarily convinced: there was evidence that a great deal of development had taken place and was still taking place without such research. Indeed, it would appear that in certain cases deterioration in the development situation had taken place in spite of a great deal of research.

A second question that was put to the meeting was whether policy orientation of research was really the overriding consideration,

whether there was not a case for distinguishing between basic research and policy orientation. The majority of the participants seemed to support the view that this distinction between basic and policy orientation was probably artificial, and might be based only on a conflict with the time horizon of the political authorities. Indeed, if one looked into the longer term, even basic research drew its major justification from its policy relevance. It may then be asked whether the usual distinction between basic and policy-oriented research should not be replaced by one between long-term and short-term research, since the policy orientation of all research was recognized. Semantics, however, could not remove the possibilities of conflict with decision-makers inherent in policy-oriented or short-term research. The more policy-oriented the research subject, the more pressure might be put on the researcher to provide the results expected by the political decision-makers, and possibly the more secretive would this decision-maker be about publicizing the results of the research if they did not correspond to his ideas. The same possibility of conflict arose still more in cases where the researcher chose not to work within the framework of the existing institutions, i.e. where he was questioning the appropriateness of existing machinery and suggesting changes. There was a fairly wide agreement that the researcher could not, in good conscience, take the institutional framework of the country in which he worked as given and immutable. It was suggested that a key requirement for good, relevant research was that the institution in which the researcher found himself should be flexible, and should permit adaptations of the research to changing circumstances or requirements as he perceived them.

Finance for Research

It was not surprising that in a meeting of research directors with their own budgetary problems the view should be expressed that the ideal would be to have a large independent budget for full-time research work, not financing of individual research projects. However, the consensus was that this was unrealistic. Given the need to attract finance, the danger that was clearly expressed was that the funding source may indeed influence the research design and methodology. It was often easier to obtain finance if the research scheme was adapted to the known biases and preferences of the funding agencies. This might be one of the reasons why developing country governments were often very suspicious of research financed from outside sources and would not necessarily cooperate fully with the researcher, which could lead to frustration. Particular criticism was addressed to the practice of tied research funds, tying apparently being understood both as requiring the employment of nationals of the funding agency and as the limiting of funds to a given project.

There was one down-to-earth area, however, where outside financing was felt to be without serious danger; this was in contributions to building the research infrastructure, i. e. books and other library materials and research equipment. Also, outside help for training would usually not present very serious problems. In addition, there was a plea for outside assistance, both financial and technical, in developing publications media of good standing in the developing world.

Those that spoke to the problem all agreed that local finance for research institutions in developing countries was not a problem; indeed, it was suggested that in some cases the general budgetary expenditure for administrative and hard-core work should all come from local funds.

Sharing the Research Tasks

Considerable attention was devoted to the question of whether it was possible to divide up the required research tasks between the developed countries' and developing countries' institutions. Discussion started with a sustained attack on the speed with which developed country institutions active in the field of social and economic development research had grown in the recent past. Concern with this fast development was fueled by the implicit assumption that there was only a given amount of research money available, and that the developed country institutions were competing for these funds with those in developing countries. It was suggested that institutions in developed countries should shift increasingly away from advisory services to developing countries and should address themselves to problems arising in their own countries, or to so-called interface issues, for example: migration, multinational companies, etc. It was also suggested that developed countries should look into the problems of their own poverty groups or ethnic minorities in preference to doing that in the developing world. In the course of the discussion, however, the meeting developed some feeling that the preceding points were addressed to problems that were disappearing.

It was noted that researchers in developed countries, like those in developing countries, were of three different types. There was one group doing research for their government, and that was the main motivation of their work. Then there was a group of people motivated by good intentions and moral issues deriving from extreme differences in income levels; and there were finally those that pursued some ideological objectives under the cover of research. None of these motivations would disappear by wishful thinking about redirecting their attention to developed country subjects. The issue therefore was not how to stop them but rather how to live with them, if possible in a mutually beneficial manner.

A consensus emerged that a division of labor in research was not

really a possibility, not only because there were no clear lines on which one could do this, but because it might also be undesirable when most research institutions had a legitimate desire for autonomy. In any case a monopoly position on any one subject should be avoided. The most one might suggest was some system of preferences for research contracts to be given to developing country institutes which could then secure the assistance of developed country institutes where required. This in fact is what is happening through the deliberate policies of a number of research sponsors.

Problems of Research Dissemination

The most important point in this discussion appeared to be the view that all research results should be regarded as the common property of the research community and should be made available universally. At present, it seemed that many of the research sponsors were unwilling to see their commissioned research results made available outside of a restricted group determined by the sponsor. Some participants suggested that one would never be able to change this, while others made a strong plea for a common stand of the research community that their research work should be given the widest possible circulation. At the same time it was noted that if research was commissioned for the immediate purposes of the sponsor it would certainly be read by the financer, even if it could not be further disseminated unless the financer agreed; but if research was not paid for by the intended user, then one had a problem since publication could always be achieved but relevant readership was more questionable.

It was noted that many institutions in the LDCs did not even have the money to distribute working papers for comments to interested research groups. It was suggested that certain central points should be established to do this, and circulate such papers to lists that may be drawn up by the authors. This was a possible role for the research associations now functioning on a regional basis. It was also suggested that some of this function of dissemination could perhaps be taken over by data banks which would provide regular analyses of publications in the field of social and economic development throughout the world.

Further discussion concerned the audience to which research results should be addressed. A strong plea was heard that when research was being financed, an allocation should be included for disseminating the results to the popular audience in the country concerned with the research. Such funds should be foreseen as a matter of course, since the policy impact of the research could be enhanced greatly if the population of the country was sensitized to the research findings. In any case, it was important that the flow

of information between developing countries and developing regions should be facilitated and increased. This was necessarily a fairly expensive process, which required, in addition, the technical capacity to carry it out. It was proposed that the regional associations of institutes be given this responsibility and the means to carry it out.

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The Role of the Social Sciences in Development Studies

Paul Streeten

[This article begins with a list of common criticisms of research in developing countries done by scholars from wealthier nations, and distinguishes elements in this criticism which are justifiable. Given that an "infant industry" approach to fostering research in developing countries is desirable, foreign collaboration can be of value; suggestions are made concerning the potential conflicts and the inequalities inherent in such collaboration.]

Development research sponsored by institutions of the wealthy nations in the developing countries has been criticized on several grounds.

(1) First, there is the charge of academic imperialism. The critics see foreign professors move into their country with already designed research projects, trying to "mine" for data and statistics, using locals for semi-skilled activities like interviewing, filling out forms and interpreting, but preserving for themselves the basic research design, processing and publishing. The "researched" country, having been stripped of its data, sees the results published in the journals or books of the industrial countries, adding prestige to the foreign professors and their institutions.

(2) Second, there is the charge that "Western" concepts and models are inappropriate for understanding the utterly different circumstances of developing societies. These "alien" concepts and models are thought to determine inappropriate policies, and either divert

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attention from the real problems or become apologies for existing power structures. For example, heavy emphasis on capital/output ratios, savings and investment ratios, the notion of unemployment and employment, aggregate income, and others have, it is argued, misled policy makers and have concealed the importance of institutional and other structural changes, such as land reform, credit and banking reform, the creation or strengthening of an efficient administrative service, or an egalitarian educational system.

(3) A more sweeping charge arises from the view that advanced country research is part of the system of international capitalism, in which under-development makes possible the growth of the capitalist countries of the West. Private foreign investment, the multinational enterprise, international trade and monetary arrangements, universities, and, indeed, research itself, all reinforce the dominant position of the advanced, industrial countries, together with a small class of privileged people in the under-developed countries. (This criticism assumes acceptance of a particular ideology.)

(4) Fourth, there is the complaint that, as a result of the concentration of funds and the accumulation of skills, the scholars from the developed countries have gained a superiority and that this superiority, combined with the institutions and attitudes derived from it and reinforcing it, prevent research institutions and attitudes in the developing countries from growing to strong and independent status. The relationship betweeen the foreign professor and the local workers is often that of patron and protégé. The patron will try to get jobs, write references, arrange a fellowship to the metropolitan country for his protégé. But the relation is one of dependence of the developing country researche: on the favors of the foreign patron. Only more inward-looking policies towards research (it is argued), and more cooperation with countries at similar levels of development, hold out hope for the growth of realistic and relevant research, based on self-reliance, self-confidence and autonomy. (This is a kind of intellectual infant-industry argument.)

(5) Fifth, there is the charge of illegitimacy which is raised when research leads to the recommendation of actions, the costs of which are borne entirely by people other than the foreigners who make the policy recommendations. There is something, if not illegitimate, at any rate distatsteful in people from safe and comfortable positions recommending revolutions or painful reforms, or for that matter, the maintenance of the status quo, to others. (This is, of course, a general point about the moral responsibility of the scientist, not confined to research on poor countries.)

To what extent are these charges justified? An analogy between mining and searching for knowledge is surely false. The more gold I have, the less is left over for others; but this is not so with knowledge.

We all can draw on the stock of knowledge and my discovery does not normally derpive you of intellectual profits from it, though it may deprive you of recognition for the discovery. More importantly, there are common standards of scholarship, which assert its universality and the solidarity of any one scholar with the international fraternity of other scholars. Commitment to the search for knowledge, to scientific objectivity and to telling the truth as one sees it, know no national frontiers. In addition to the intrinsic value of this commitment, loyalties to universal values that cut across frontiers have their political value in an age when nationalism and ideologies have become dominant secular religions. In this sense, therefore, there cannot be African, Asian and Latin American criteria for truth or validity. Mining companies can be nationalized; criteria for truth cannot.

The problem is, however, complicated and sometimes confused by people mistaking truth for logical validity, and the criteria of truth for empirical content. For if economics is equated with universal "logic of choice," it would follow that there is only a single economic science from China to Peru. Yet clearly, if we turn from the standards and criteria by which we judge methods and conclusions to the content of our work, it should be plain that very different propositions are likely to be true for different societies. In this sense, it is perfectly legitimate to speak of "African," "Asian" or "Latin American" economics or politics or sociology. It is this confusion between validity and truth, to which some economists have themselves contributed, which is partly responsible for what appear to be nationalistic attacks on the "legitimacy" of "Western" social science.

It is part of scholarship to recognize the limitations of propositions which may be applicable to one region or period but not, or not without modification, to another. It is understandable that territorial and temporal claims of the validity of certain theories have tended to be excessive and that there is, for this reason, an element of "imperialism" in the generalizations of social science. But this sense of "imperialism" is, of course, entirely different from the one discussed above. Thus, it can be argued that important elements of Marxian "scientific socialism" are universalization of the experience of industrial England between 1780 and 1840, when inequalities increased and when, in the midst of farily rapid industrial progress, the poor may, for a time, have become poorer. Keynes' so-called General Theory of Employment, Interest and Money is a rather special theory, applicable to the grossly underutilized resources in industrial countries during the depression of the 1930s. And one could go on: the Ricardian theory of distribution, the Malthusian theory of population, various theories of secular stagnation, secular inflation, secular doom, may all be projections onto a vast historical

screen of the snapshots of a few years or decades.

It is qute legitimate, in the service of universal truth, to criticize orthodox Western models for their excessive claims, for their "intellectual imperialism." It is in the interest of honest work to assert that in Africa, Asia, Latin America, at very different levels of development, in a different demographic setting, in tropical climates, in a different international system, etc., they order things differently. Such limitation of excess claims, where it is legitimate, should be recognized as legitimate by scholars wherever they may be. At the same time, I believe it can be shown that at least some criteria of truth and validity cannot be dependent on social, cultural, linguistic or other existential factors. Indeed, even asking questions about differences between beliefs and theories presupposes logically universal and fundamental criteria of truth with respect to the answers.

Nevertheless, the concepts, models, premises, assumptions or questions asked in the social sciences are in some respects particular. I conclude that there may be an African economics as distinct from a European economics; but there can be no African truth. By rigorous analysis, by accumulation of evidence, and by bringing out explicitly the value premises assumed, errors and biases can be reduced. There will, however, remain a residual of ideology, and this residual element may be particularly misleading if transferred from the experience of industrial countries to developing countries. It is for this reason that the assertion of the universality of the criteria for truth must be qualified, although the remedy cannot be found in erecting a barrier against "alien" doctrines.

There is a second element in the charges of Western intellectual predominance. While the stock of fundamental knowledge may in principle be drawn on by anyone anywhere, the resources that enable scholars to conduct research are, of course, scarce; and the recognition, prestige, and fame that are the reward of successful work are competitive and by no means a free good. Recognition attracts funds, and funds make it possible to gain recognition: a cumulative process that will tend to penalize ill-endowed centers of learning. No money — no ability to train and attract good scholars; no recognition — no money. It is then understandable if institutions starved of funds in the developing countries should resent the well-endowed foreigners who use their work in the developing country to gain further recognition and hence even more funds. If this "invasion" is then accompanied by concepts and models that are unrealistic or ideologically biased for which excess claims are made, and if the behavior of the foreigners is tactless or patronizing, it is understandable that the indigenous scholars will charge the foreigners and their doctrines with being dominant and arrogant and that they will not wish to engage in joint ventures.

There is also an understandable feeling that opportunities and facilities to present, exchange, develop and communicate ideas are much greater in the developed countries. But while this may sometimes give non-Westerners the impression that they are facing a well organized intellectual phalanx of social scientists, it does not follow that these people are acting in the service of Western political or economic imperialism (charge No. 3) — if only because a number of these social scientists are demonstrably "anti-imperialist" in their thinking. There is, however, justification in the charge that well-endowed and established institutes operate from a position of dominance, and in the fifth charge: it is all too easy to be a radical, a revolutionary, a reformer, or, for that matter, a conservative, for another country.

Having said all this, it must be reasserted that a universal commitment to scientific research, and to presenting its conclusions as one sees them, are fundamental to all scholarship. Tact and diplomacy are, of course, necessary if recommendations are to be adopted by governments. But this must not affect the content of basic research, partly because it would offend against the principles of scholarship and partly because policies based on blinkered analysis are bound to fail. I conclude that knowledge itself is a common good, and that its pursuit unites scholars across the world; that scholarship rejects diplomacy and tact, though sensitivity and imaginative understanding are essential in social studies, and tactics are in order if implementation is desired. At the same time, it needs to be recognized that the infrastructure of well-endowed research — seminars, conferences, country houses, institutes, universities, travel grants, sabbaticals, etc. — is subject to increasing returns, so that polarization, dominance and dependence will tend to be established. There is thus an intellectual and economic infant industry argument for encouraging research in the centers of developing countries, even when it is initially of a lower standard than research carried out in established centers; but there is no argument against exposing ideas to world-wide scrutiny and criticism.

Equal Partners in Research?

External assistance can be of value in fostering an "infant industry," and research links of developed country centers with departments or institutes in developing countries are now generally advocated. But it is not always clear what particular purposes these links can best serve. One might distinguish the following objectives from the point of view of the scholar in the developed country. (Different objectives would be listed if we looked at joint ventures from the point of view of the developing country or its scholars.)

(1) In order to conduct research in a particular country, a link

with a domestic institute is helpful. It provides a source of data, collectors, interviewers, interpreters and other useful local resources.

(2) The link may help to gain approval for conducting the project from the authorities; it may remove criticism from the local press or public opinion; it may make it easier to gain access to certain sources of information, or may even be essential for this.

(3) A link may be though necessary in assisting in the dissemination and application of policy-oriented research. Domestic institutes have often special links with government agencies and other policy-making bodies.

(4) In some cases, the prestige of foreign institutions is greater than that of domestic ones in the developing countries. A link may then serve to add acceptability to the work of a local institute, even though the foreign link is only tenuous.

(5) The link may be intended to build up and strenthen indigenous research capacity, whether of individual skills or of whole institutions. It is generally recognized that such capacity is highly desirable in itself and is a necessary condition for development.

(6) A link may be desired in order to improve, through the association, the teaching capacity of the sponsoring institution.

(7) Finally and ideally, the local institute may contribute professional expertise at the highest level. The indigenous scholars, being more familiar with the society and the local problems, may improve the design of the research project, may help to ask the right questions and prevent errors, and may contribute to the right balance of emphasis.

Some of these objectives could be pursued jointly; but conflicts may arise. Collaboration agreements and joint ventures, in scholarship as in business, may be forms of window-dressing. They may pretend that dominance and dependence do not exist where they do. In such a situation, objective 5, help in building up research capacity (which may include help in reducing a heavy teaching load or help in reducing the time spent on supervising and organizing research of others, by the few who could be better employed in doing the research themselves), may have to precede objective 7, that of genuine collaboration.

This roundabout way of strengthening research capacity raises important and difficult issues. The problem is sometimes presented as a trade-off between strengthening indigenous research skills and research quality. At least three questions should be asked: (1) What is the purpose of the support: is it research or training for research?

If training, is the intention to create or improve individual skills or whole institutions? (2) What is the time horizon? Is it important to have results of the highest quality soon, or is it preferable to forgo speedy results for the sake of more and better results later? (3) What risks is the donor prepared to take? The results of backing underdeveloped research in order to strengthen its capacity are even more uncertain than those of backing highest quality research. Some projects will fail or be disappointing.

The most fundamental argument for international cooperation in development is that human beings, wherever born, should be able to develop to the fullest extent their capacities, both in order to fulfill themselves and to contribute to the common heritage of civilization, of which the stock of knowledge is part. In the light of this, the so-called trade-off between quality and capacity appears as an inter-temporal choice with an element of risk. But, human beings being what they are, it will be difficult to find ways in which the facts of initial superiority and inferiority can be acknowledged and eventually removed.

For objectives 1-4 collaboration is often more honest and more practical if both partners get something out of it. There is no objection to introducing an element of trading: you help me in getting data, and I help you with designing a curriculum or reducing your teaching load. Arrangements for mutual benefit, not all of which need directly relate to the research project, are possible and often desirable. One practical conclusion is the need to encourage and finance scholars from developing countries to conduct research in developed countries on the problems of these countries, and on the problems generated by the world system of international relations. Only through such reciprocal and symmetrical arrangements can the idea of international cooperation of equal partners in research be realized.

When the participation and collaboration achieve complementarity, can there be also specialization, a division of labor between research in developed and in developing countries? It might be argued that most basic research should be conducted in countries where sophisticated human capital and institutions are more plentiful, and that developing countries should confine themselves to adopting and adapting basic research from the industrial countries and direct their own efforts at research that can be applied quickly and can best be done locally. Yet, such a conclusion would be misleading. First, the ability to adopt and adapt requires a research capacity not too dissimilar from that in the developed country. Workers must be able to appraise critically what is useful and what is not, and how the useful can be adapted. This ability presupposes research capacity of the same order and of the same depth as that of the original workers. Secondly, in view of the international market in professional

social scientists, developing countries may have to attempt to match, or nearly match, the research opportunities their best brains are offered abroad if they wish to keep them. And keeping them may be a necessary condition for carrying out useful applied research with quick-yielding results. For both these reasons — the need of an indigenous basic research capacity in order to adapt, and the need to plug the brain drain — developing countries cannot simply confine themselves to applied, quick-yielding, locally relevant research plus adaptation of research from abroad. They too must engage in basic research.

But there remains the question of balance and direction. If scholars are induced not to leave their country but carry out the kind of irrelevant, esoteric, abstract work that gains prestige in the centers of learning of the developed countries, little is gained. How this can be prevented raises difficult questions of academic prestige, social concern, conflicts between social and professional priorities and individual motivation. On these grounds a case might be made out for some closing in of the scholars of the developing countries, for selectively reduced contacts with the international community of scholars, if such turning away would encourage attitudes more in line with social priorities. On the other hand, if the scholars in the developed countries recognize that what is regarded as "the best" in one setting might be the enemy of the good in another, and if they adjust not only their research priorities but also their pecking order of recognition and prestige, then the objections to international cooperation across wide-open frontiers are weakened or removed. Paradoxically, by lowering the claims of prestigious subjects and "standards of excellence," and by making analysis more flexible, standards less universal, and policy recommendations more diverse, a greater universality and better international collaboration can be achieved.

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Research and Rural Development Policy in the Philippines

Gelia T. Castillo

[During the past decade a number of institutions concerned with rural development have grown up in the Philippines, and their research work has become variegated and active. This article discusses a number of interactions between research and policy making, noting some successes and also areas in need of further exploration.]

Within the present context of rural development, research for intellectual curiosity's sake is neither prestigious nor fundable. Such pursuits may be found, but whatever exists has most likely been proposed under a rural development umbrella, although this is still so encompassing that it is hard to determine what it excludes. With this policy emphasis, the greatest challenge to the social scientist lies in the creative translation of practical problems into researchable ones which will yield solutions or answers to the practical questions which have been asked by developers. Often there is a chicken and egg problem: research helps define the magnitude and dimensions of rural development problems, but a definition of these problems also defines areas for research. In other cases research arises from policy decisions. For example, political sense and social pressure has brought about a land reform program; but having decreed the Emancipation of Tenants there is an urgent need to determine size of holdings and who holds them. In the process of program implementation, it was found that a majority of the landowners are quite small owners. Having made a previous pronouncement that development of a strong middle class is a desirable national

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goal, a possible conflict between the stated policy and the reality was perceived by policy makers. A study is now underway to ascertain who the small landowners are in order to have a basis for either changing or pursuing previous policy.

There are six general types of rural-development-oriented research, of which two will be discussed further below.

(1) Research which indicates or defines a development problem and suggests what policies might be needed to solve the problem.

(2) Research that arises out of problems associated with implementation of policy, such as land reform.

(3) Research that is stimulated by policy consequences, e. g. the multitude of studies generated by the "green revolution."

(4) Action-research, which includes intensive studies of particular approaches to rural development: case studies, pilot projects, "experiments" or social laboratory.

(5) Evaluation studies of rural development programs.

(6) Studies which integrate results of researches that focus on particular development problem areas.

Integration studies. Because the Philippines has a proliferation of social science research centers, research integration projects are almost indispensable, not only for determining what is known and what else needs to be known but also as a "collective" device for reaching decision-makers. Equally important is their potential usefulness to teachers, who seldom have access to a wide range of local research-based materials for teaching. What comes handy to them are American books. Since our social scientists do not perish if they do not publish, research results tend to remain in typescript, in mimeographed form or in graduate student theses, most of which are circulated only in limited numbers, if at all. In the meantime, considerable investments have been made in every research undertaking, reports of which are sometimes known only to the researchers and the funding agencies. The latter may not even have the time or the inclination to read them. The need for pooling together, codifying, analyzing, integrating and interpreting available data and research results is evident in the priority concerns of the major social science outfits, but little along this line has been accomplished.

The integration of research findings should be done not by discipline but by development problem area, such as: agrarian reform, credit, impact of agricultural innovations, family planning, non-formal educa-

tion, etc. An annotated bibliography, although informative and useful, is not as valuable for identifying gaps in knowledge and as a basis for research priorities as an actual analysis and synthesis of research findings, many of which might be conflicting. Two examples of research integration projects are W. F. Stinner's, "Levels, Trends and Differentials in Philippine Nuptiality, Fertility, and Family Size Ideals and Preferences: An Integrated Summary of Research Conducted under USAID Contract" which was done for the Population Institute; and "All in a Grain of Rice: A Review of Philippine Studies on the Social and Economic Implications of the New Rice Technology." The latter, which was done at Los Baños, includes a synthesis of researches in land reform, employment and income distribution, diffusion and adoption, credit, cooperatives and other organizational components, the rice farmer, and agricultural extension services, all of which have some relation to rice.

Despite the demand for it, the research integration job is not a glamorous one. It is a long and tedious process, and no matter how creatively one goes about his task his study is viewed as a mere compilation of other people's work. The attraction is still toward the opportunity to do "original" projects under one's own byline. Despite frustrating attempts to secure support for research integration work, an occasional bright spot appears in the latent interest which one or two funding agencies have shown. What is curious, however, is that one agency might support the research integrator to do the job but will not bother about its publication. Another agency would argue that they cannot support such a project because they are not smart enough to predict how good a job the person can accomplish; but as soon as the manuscript is completed, they are eager to pay for its reproduction. Still another agency would support a research integration project because they are interested only in using the research integrator to bring together many fugitive materials which they themselves could never get. He is even made to understand that they have no obligation to publish his manuscript; neither is he free to use the materials after they have been submitted — somebody else is to use these materials. Fortunately, contact with more than one funding agency provides some alternatives. And when policy interest is strong enough, research may even be integrated — or at least orchestrated — in advance, as in the fields of population and education (see below).

Action-Research. One area that deserves as much research investment as the formulation of policies is the dynamics of getting things done, the process of implementing whatever policies have been adopted. In this area the services of the Filipino social scientist seem to be in demand, but it is probably in this area also where he is most ill-equipped, research-wise; and the extent to which the policy maker or program administrators take into account the re-

search results as interpreted to them by the social scientist is difficult to determine. He is asked to participate in programs for rural health, credit, cooperatives, irrigation, agricultural innovations, family planning, agricultural education, applied nutrition, employment, rural-urban migration, regional development, etc. For this task, action-research has much to offer to the researcher's repertoire of insights into the development process. It documents and analyzes the process by which a particular rural development strategy is introduced, accepted, rejected or modified, and its impact on the object of development. Dozens of projects can tell us the before and after circumstances of a development situation, but what takes place in between is rarely studied. In other words we need to know much more about the nature of the "stimulus" or the strategy itself which brings about change, and if it does not why not.

With an action-research project, the research input required to satisfy project objectives is substantial, dynamic, and continuous. Let us take the case of a pilot project in multiple cropping which has the following requirements, all of which call for a major social research investment:

(1) To develop a pattern for introducing multiple cropping to farmers for adoption.
(2) To study the processes involved in the introduction and adoption of multiple cropping.
(3) To identify the technological, educational, sociological and economic problems in the introduction and adoption of multiple cropping.
(4) To determine the economic and social development impact of multiple cropping.

The expected pattern for introducing multiple cropping is really a kind of social technology and is an integral part of the agronomic package which makes up multiple cropping. Without the necessary research input, only the direct participants in the project will learn from it, and therefore the whole raison d'etre for the pilot project is defeated and lessons gained from the multiple cropping strategy cannot be effectively shared.

Action-research by its very nature leads to a lot of role confusions and conflicts because research action and evaluation are simultaneously carried out. The situation is complicated even more if a university administrator also happens to be project leader, researcher and evaluator at the same time. He will find it difficult to separate an administrative report, which justifies project support, from the research report, which documents and anlyzes the various dimensions of the action program which is the object of study. For example, a report of accomplishments which includes the number of visitors and VIPs who came to see and were impressed by the project is a public relations messgae, not a research report. To illustrate further, if an action-research project were to report the case of 80 small farmers who were able to obtain loans totalling P150,000 under an integrated farm-financing program, this would

not be a research accomplishment. The object of the research is to analyze the process by which farmers came to borrow from the bank for multi-production purposes.

There are at least three social phenomena worth investigating in this regard: (1) banks do not usually lend to small farmers without collateral, etc.; (2) small farmers in the area are usually oriented only toward rice; and (3) the emergence of an integrated farm production and financing scheme is a very modern phenomenon which entails a great deal of risk and sophistication. Certain social mechanisms must have been introduced to make this development possible. An identification, description and analysis of such mechanisms would be a research achievement. The problems of combined roles in one project are not insurmountable, but the research role has to be exercised with the utmost professionalism. Despite inherent difficulties, these types of projects are invaluable in the study of rural development strategies and the intricacies of the development process. One other problem in carrying out action-research is the relatively long-term commitment (at least 3 to 5 years) which is required. Within this period the project is subject to personnel turnover, natural calamities, major political changes and competing alternatives for the researcher's time. These drawbacks, however, can be assets in the sense that the project has a chance to respond to natural events which normally occur in the lifespan of a development program, and useful lessons may be learned from such experiences.

Research Priorities

There are at least four types of priorities for development research:

(1) Systematically determined priorities based on an analysis of rural development problems in the light of what is considered desirable as national goals. Coupled with this is a synthesis of past and current research findings which will point out what the necessary "unknowns" are.

(2) Natural inclination priorities (a euphemism for vested interests) dictated by the importance of whatever is germane to one's particular field of study or apropos to one's professional advancement.

(3) Opportunistic priorities determined by the very pragmatic consideration embodied in "Tell me what your angle is as a funding agency, and I'll come through with an appropriate proposal." Officials of funding agencies wittingly or unwittingly evoke this type of priority.

(4) Induced priorities set by someone who possesses knowledge or money or both and exercises persuasive powers over researchers. This is not at all bad if he happens to be very wise and very rich!

Policy Linkages

Because development research is supposed to contribute to the development process, the nature of the links between research and policy is always a pertinent question. In the Philippines these links, whether tight or loose, take several forms:

(1) Personal, informal and/or professional interaction, advising or consulting which takes place on an ad hoc basis between researcher and policy maker.

(2) Seminars, workshops, conferences organized by development agencies to which social scientists are invited to present papers, serve as resource persons, etc.

(3) Research commissioned by development agencies. Hopefully, research results are at least read, if not used.

(4) Dialogues between social scientists, policy makers and program administrators at the latter's invitation.

(5) Social scientists themselves become policy makers or perform two roles concurrently.

(6) Training programs for action workers and development administrators where research results are used as training materials.

(7) Social science graduate courses where students come from rural development agencies. Upon return to their respective agencies, they almost always occupy key positions.

(8) Social science publications. Because they are quite often addressed to other social scientists they may only be of marginal utility to the policy maker.

(9) Social scientists working in development agencies in a research and evaluation role.

(10) Research communicated via an intermediary. Where there is a residual colonial mentality in the policy maker, the researcher passes on his research findings to the foreign expert who then gives his advice with or without mentioning the source. It is not uncommon, however, for the foreigner to build up the local researcher in the eyes of the policy maker by putting in a good work for the research he has done.

One or a combination of several of these ways of reaching policy-makers and developers may be found in the different institutions engaged in development research. These avenues are utilized not only for domestic but also for regional or international linkages. Some of these methods have more direct and more immediate impact on policy than others, but formality of arrangement is no guarantee of effect. The "whispering" linkage, depending upon who is whispering to whom, works wonders in many ways.

Two examples of study series which have been the basis for major development policies are those on population and education. The former have been responsible for generating much of the basic facts and figures without which it would not have been possible to argue that we have a population problem. A series of conferences on the subject provided a forum for academicians, practitioners, and policy makers including church authorities. With intensive cooperation from the media, all the research papers have contributed immensely to the definition of the population problem and its implications. They helped to objectify the issues involved and to banish the undercover and sensitive nature of the proposed solutions to the problem. Eventually a population policy was arrived at and a population program was evolved. In the case of education, studies were conducted by the Presidential Commission to Survey Education, and their recommendations on the basis of survey findings were adopted for implementation almost in toto via a Presidential Decree.

Multidisciplinary research. Today everyone wants to be multidisciplinary, inter-agency, integrated, coordinated, programmed systems-oriented, and of course relevant to national development. The overwhelming concern over multidisciplinary research might be misconceived: if one were to focus on the problem rather than on the academic discipline, every development problem is by its nature a multidisciplinary phenomenon. After all, the boundary between academic disciplines is an artificial one, created by academicians and imposed on the phenomena we are looking at. Many so-called multidisciplinary research projects are in reality simultaneous research problems within the same project pursued parallel to each other, and they may or may not meet within the covers of one research report. As somebody said: "the best type of interdisciplinary thinking is one which takes place within the same skull."

In real life, the academic dichotomy between technical and social factors is less of a dichotomy and more of a unity. Every physical or biological piece of technology such as irrigation, new rice seeds, power tiller, etc., is developed within an organizational framework and introduced into a socio-cultural physical environment. The research which led to the development of new rice seeds is a social activity carried out within a particular social setting. The social organization within which they were introduced is as much a part of the new seeds as their eating quality or tillering capacity. Although little has been said about it, there was some form of social technology which accompanied the introduction of the new rice seeds. Two examples of this social technology are: (a) Changing the change agent, a system whereby the extension workers were asked to go through the entire process of rice production from land preparation to harvesting. This not only gave them the necessary knowledge and skills, and the self-confidence to enable them to face experienced farmers, but also helped to develop a new reference group in terms of work norms. (b) Applied

research plots in farmers' fields introduced the concept of experimentation to the farmers, while at the same time reducing the extension worker's risk of making the wrong recommendation as to which combination of seeds, fertilizers, etc., would work best in the farmers' particular situations.

The development-oriented social scientist is therefore a special breed of researcher. He has to be interdisciplinary within himself. He must comprehend and appreciate the basic ABCs of rice production if the subject of research is the impact of new rice technology, or his social science training could lead him to the wrong conclusions. Unwillingness to apply fertilizer could be interpreted as traditionalism when it is rational non-adoption because of the nature of the rice variety being used and the soil in which it is planted. Agronomists, for example, who have been working on the development of improved cultural practices for the production of coconuts, abaca, etc., should come to the social scientist to ask: "Who is the coconut farmer? Who is the abaca farmer?" If they are to introduce innovations in production they need to know who their clientele is. They also want to know how many such farmers there are, where they are and what kind of people will benefit from whatever new agricultural technology they develop. The social scientist in turn can respond much better to these questions if he knows enough about coconut production, abaca production, etc.

Statistics. It is extraordinary how much of our analysis and definition of development problems is dependent on the statistics that we use. When the data base is in question, whether in terms of methodology or integrity of the statistical system, one cannot escape bedevilling doubts as to whether the development situation is what it is in actual fact, or whether it is just the statistics which have made is so. For example, the Bureau of Census and Statistics reports the 1970 population figure as 36,684,486. The Population Institute disagrees and says that the total is 37.8 million. The difference of more than a million represents only 3 percent of the BCS figures, but 1,115,524 Filipinos means a difference in our computed rate of population growth which in turn affects family planning targets, food production requirements, etc. Data on rice production are another source of policy headaches. For example, in October 1971, the National Food and Agriculture Council reported that the yields of high-yielding varieties continued to average about double those of the traditional varieties. If these estimates were accurate, the Philippines should have been exporting large surpluses of rice instead of importing in 1971. On the other side of the coin, a well-known social scientist once said: "Sometimes the policy maker uses research the way a drunkard uses a lamp post, for support rather than for illumination."

Issues in Need of Research

Extensive exposure to rural development in the Philippines tells us that certain research approaches deserve to be applied more, and certain substantive areas have either been ignored or insufficiently noticed. Then, too, one acquires misgivings about the assumptions we make in rural

development and nagging second thoughts disturb the professional and social conscience. There are at least seven issues for consideration:

(1) The need for a planned complementarity between the micro and macro level research, and a more problem-focused research orientation which fuses rather than divides the physical, biological and social aspects of a development problem. An excellent illustration of what this means is provided by Sodusta's research on Manpower and Wet Rice Cultivation in Jamoyawon, Siargao Island, Northeastern Mindanao, 1973.

One of the fears generated by the advent of the new rice technology is that labor-saving devices would come into greater use and human labor would be displaced. When we reckon the size of our labor forces in aggregate terms, we arrive at the conclusion that we are a labor-surplus economy. Setting aside this macro-level view, Sodusta proceeded to examine in depth the manpower situation in rice production as it is practiced in a very poor community. Using intensive time and motion study for a close-up view of actual work performance, she concluded that labor resources for rice production are inadequate due to the shortage of "qualified" skilled workers. Three major reasons account for this shortage: (1) a high percentage of children among the village population; (2) available labor force is engaged in a variety of household and other nonproductive activities which are essential to everyday life; and (3) majority of the labor force are undernourished or malnourished. Because life must go on for the peasant, adjustments to the labor and energy shortage in rice production are made in the following manner: (1) four or five carabaos are used for land preparation, but of all the activities engaged in by the peasant, caring for the carabao occupied most of his time; (2) the different stages in land preparation are combined, shortened, or omitted in order to save time and labor; and (3) to cope with the energy requirement in land preparation considering calorie-protein deficiency, the peasant spends much time sitting idly between tillage activities and taking a nap or resting. After this intensive time and motion analysis, Sodusta expressed misgivings about the present preoccupation with multiple-cropping as an answer to what is defined aggregatively as a labor surplus problem. As she suggests: "the numerical size of the household is a poor indicator of the strength of the household." In the same vein, the size of the labor force is an inadequate indicator of effective manpower for production. We may have a labor surplus but human energy shortage.

(2) Equal research attention to the structural measures for income distribution and employment as well as to the traditional cultural means for bringing these about. For example, rural communities have traditional practices for work sharing, harvest distribution, income transfers and social levelling. About 20 percent of Filipino households depend on family assistance, gifts, etc., as one source of income. With more efficient and effective tax measures, a higher per-

centage of family income will be transferred to the bureaucracy which, in turn, will redistribute these via social security, old age pension, scholarships, medicare, funeral benefits, etc. There is nothing wrong with these measures except that a government, no matter how benevolent, is impersonal and can only show how much it cares via the IBM. We need to think of ways to mitigate the Western system whereby an old man receives a welfare check and food stamps but no love and affection. Our family social security and old age insurance system might have little money but provides a lot of love. Can we combine the desirable features of the Western and the Filipino systems? What creative fiscal devices can we try out to achieve this end?

(3) As much concern for currently landless and potentially landless agricultural labor as for small owner and tenant cultivators. At the moment there is little or nothing known about them which will enable us to promote their welfare. The land reform program is practically silent about them. We do not even have an estimate of how many they are, and labor laws hardly touch them.

(4) Studies of the impact of reduced family size on traditional functions performed by the family. Can the economists calculate how many children we can afford to have in order to achieve growth without undermining the basic character of the Filipino family? Shall we "stop at three" or "quit at five"? Nobody knows. We simply want to have fewer children. If we have three instead of 6.8 children, to what extent do we have to put up old folks homes, lay out "head shrinkers couches," and set up singles bar? In short, if at all possible, we want to "have our cake and eat it too."

(5) Reexamination of "dead ends" we have left to our young people. Rural youth as a development problem area is suggested by the following: (a) From 5.37 million in 1965, the youth aged 14-21 increased to 6.39 million in 1970, an annual growth rate of 3.0 percent. This age group comprises 16.9 percent of the total population. About 4.2 million or 65.6 percent of these young people are located in the rural areas. Only minor migrations to the urban areas occur within this age group. (b) Of the total youth employment in 1967, around 1.013 million or 63 percent are engaged in agricultural work. (c) There is a noticeable shift of youth employment toward agriculture. In 1965, the youth engaged in agricultural work was 57.6 percent; this increased to 64 percent in 1967. These young people are usually engaged in minor routine farm jobs. (d) About 300,000 young people were unemployed in 1967. Nearly half of them are females, and the proportion of unemployed youth who are located in the rural areas rose from 60.8 percent in 1965 to 64.0 percent in 1967.

Because of our preoccupation with the problem of the educated unemployed, we thought of limiting entry to the University. This is the one last hope of rural people for upward social mobility for their children. In the meantime we are also told that the absorption rate of vocational school graduates is very low. We likewise want to discourage rural youth from migrating to the city. What alternatives do we have for them? There are worse things in the world than being educated and unemployed,

and one of them is being uneducated and unemployed in a poor village even if the fresh air is free.

(6) More research involvement in the various rural development strategies which are being vigorously pursued. A most important task is to determine who are the participants and beneficiaries of rural development programs. Although the international development experts pay homage to the poorest 30 or 40 percent when rural development programs are planned, there is some reluctance to put in the resources, the time and the manpower needed to reach them.Helping the poor is not only a very expensive proposition; it is also a very special proposition which requires special projects. The latter are not easy to "sell" because they are special and therefore may not be duplicable. To what extent do we end up assisting those who are a little bit better off, relatively speaking?

(7) Social indicators and the quality of life: With the current misgivings about GNP and per capita income, the development of social indicators is now becoming fashionable. The international banks want a quantification of social benefits from their new integrated development projects. Indices such as number of hospital beds, doctors, nurses, etc. per 10,000 population; kilometer of roads, average electrical energy consumption, etc., can be as misleading as GNP and per capita income. To be "socially" meaningful, such indices should convey the distributional aspects of the benefits. For example, the national average per capita consumption of electrical energy in the Philippines is 177 KWH. This may be low or high relative to indices in other countries. A development policy-relevant indicator of electrical energy consumption will contain the following additional information: Luzon has a per capita consumption of 300 KWH; Mindanao 70 KWH; and the Visayas 27 KWH. Of the 66 provincial area groupings, only 12 show a per capita consumption rate exceeding 100 KWH, five areas have a consumption rate of between 50 and 100 KWH and the rest have a consumption rate between 0 and 50 KWH. During the fiscal year 1971-72, about 22.5 percent of the total population were served with electricity. Of this, 50.7 percent reside in Greater Manila, 19.4 percent in chartered cities and 29.9 percent in rural areas. Fifteen out of 16 families in the countryside do not receive the benefits of electricity.

What social indicators are relevant should depend upon what is considered desirable by a particular society. But the prevailing thoughts on the quality of life of the Southeast Asian border on the poetic. As Puey Ungphakorn puts it: "Healthy air, beautiful scenery, clear streams and the like are free in the countryside: this environment which helps to compensate for the farmers' low income must be preserved for them and their progeny." In our preoccupation with preserving the environment, we tend to forget that there are two types of "pollution" — one which accompanies poverty and another which comes as a byproduct of affluence. If the choice is between these two evils,

one wonders if the farmer will opt for the healty air and the beautiful scenery. It is rather poor compensation for what he hasn't got.

We have now gone full circle in our concept of rural development. In the early 1950s we though community development should take a holistic approach, and so we had manifold programs and multipurpose workers. Then we went to the other extreme of promoting single commodity production programs; and currently, we are agog about integrated rural development. No one can disagree with the proposition that "the objective of rural development and welfare is the improvement of the quality of life of the farmer in its totality, more than just increasing productivity," but can we improve the quality of his life without increasing productivity? The food problem is still very much with us, and we are a long way from solving it. If we forget this, the lowest 40 percent whose welfare we want to enhance will suffer most.

Two decades ago, rural development looked relatively simple. Our President Magsaysay stated in 1956 that: "The little man is entitled to a little more food in his stomach, a little more clothes on his back and a little more roof over his head." Nowadays what we want for the villager has been considerably expanded to include literacy; a fulltime job which uses labor-intensive intermediate technology (with no disguised unemployment or underemployment); an acre of land he can call his own; an infrastructure of facilities and services such as electricity, roads, communication, low cost-credit, health and medical services; not only higher income but more equitably distributed income. We envision high quality, development-relevant schooling for his children; decent housing; a long, healthy, adequately-nourished life with only two instead of 6.8 children, living in a pollution-free environment. In addition we prefer that he remain in the village in order not to crowd our cities. Finally, we want him and his villagemates to get organized to solve their own problems in the true spirit of self-help.

With all these complexities which have been introduced into the concept of rural development, it is inevitable that the old-time missionary zeal would no longer suffice. We have almost convinced policy makers that we need social science to fathom the imponderables and to lead us to the "paths of righteousness" in development. In the meantime we have created full employment for ourselves. But some humility is in order. The Filipino social scientist has come of age. He is respected and he is asked for his contribution. He has discovered his Asian neighbors without giving up his Western friends. For his long-term survival, he should not bungle this golden opportunity by overselling what he cannot deliver.

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Self Reliance in Social Science Research

Godfrey Gunatilleke

[The Marga Institute for economic and social research of Sri Lanka has a record of self-reliant policy and independent research in its four years of existence. After a brief summary of that experience, this article goes on to examine the issues bearing on self-reliance in developing countries which are necessarily dependent on knowledge transfers from developed-country centers of learning.]

Marga's Creation and Financing

The idea of creating the Marga Institute took shape when the Marga Journal was first published in 1971. The institute itself was formally established in April 1972 as an autonomous non-profit organization. At the time it was set up it had no foreign financing of any type, neither was there any immediate prospect of such financing. The group of persons who joined to form the Institute were able to provide a small capital fund out of their own limited resources which was sufficient to finance its work for the first few months. Immediately after it was set up, the Institute was invited to participate in a project initiated by the UNRISD (United Nations Research Institute for Social Development) and the payment for the study prepared for this project provided additional funds. Certain members of the Institute who had undertaken a study for the ECAFE before the Institute was set up were generous enough to bring the Institute into the project, and this provided another souce of finance.

During this period the Institute was preparing its

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own program of research, for which it sought financing from several sources. At this stage the Friedrich Naumann Stiftung, a private German foundation, expressed interest in financing four of the projects included in the Institute's research program. At the same time Marga received a grant from the International Development Research Center (IDRC) in Canada to finance a longitudinal rural studies program and a smaller grant for a regional low-cost housing study. In obtaining foreign support, Marga has followed a policy which safeguards the Institute's research autonomy and freedom of action by diversifying its sources of financing. The Friedrich Naumann Stiftung's support now constitutes only 30-35% of its total expenditure, and it will decrease further in 1976 and 1977. This is in accordance with the policy of the Friedrich Naumann Stiftung which seeks to promote self-reliance and withdraws its assistance under a phased program. The Institute has also collaborated with United Nations organizations in a number of studies. These include ESCAP, UNRISD, UNICEF, UNCTAD, and ILO.

Part of the Marga budget is now financed from income out of a Trust Fund which is invested in Government securities and earns interest. The Trust Fund was planned with the objective of reducing the Institute's dependence on financing which had to be arranged from project to project. Part of the Fund was financed with the Institute's own earnings, and part with an outright grant from the Ford Foundation negotiated on the basis that it would be a once-for-all grant. The only condition attached to the grant was that it be regarded as capital and placed in a Trust Fund to earn interest which could be used for the Institute's current expenditure. The Trust Fund is, of course, the Institute's own creation and is entirely under its executive management. The Institute plans to build the Trust Fund to a level which will eventually guarantee its financial autonomy.

Research Program Design

In all the studies undertaken by the Institute, Marga has selected its fields of research and designed its research program on its own understanding of national priorities without direction from the fund-giving sources at any stage. The four programs funded by the Friedrich Naumann Stiftung, for example, included a study of rural youth unemployment, a comparative study of work motivation in public and private sector enterprises, a survey of youth organizations, and a program of translations of internationally reputed writings in a selected range of disciplines. The rationale behind our program of work forms an integrated research strategy that has been discussed in other issues of this Journal. One need only state here that the Institute's research is directed at a selected range of critical problems in our country's development process — problems of youth unemployment, of socio-economic change in the village, the structure of relationships in modern enterprises, problems of urbanization, and so on. We have also participated in regional and international studies undertaken by United Nations organizations that were part of a

program designed by these organizations to formulate new global approaches to development problems and to identify effective types of technical assistance. By participating in these studies the Institute was not only able to establish a network of contacts with research colleagues in other developing countries, but also facilitated the flow of comparative research experience into our country.

In the preparation and designing of projects, as well as in the participation in regional programs, the Institute has relied entirely on local personnel. The Marga Institute does not carry any foreign researchers or other foreign personnel on its staff, and at no stage did it receive the "expert assistance" of foreign personnel that has been customary for similar institutions in Sri Lanka. Expert assistance is neither a good nor a bad thing merely on account of its foreign origin. The Institute might have benefited if it had had a few foreign researchers on its staff, but its circumstances made it rely entirely on the local resources that were available.

The Institute has sought to develop its own mode of inquiry and methodology in approaching the complex social realities of our society in Sri Lanka. The Work Motivation Study was designed very differently from most other studies undertaken locally. Most of these other studies had been carried out by local researchers either in collaboration with or under supervision of foreign scholars and often tested the hypotheses and theoretical models evolved in the West. The Marga project followed a methodology which exposed the researchers in a more comprehensive and immediate way to the primary material they had to study, and made a comparative analysis of the structure of relationships in selected public and private sector firms.

Innovative efforts were made in our rural work to combine village surveys with village level seminars in which the articulate groups in the village participated in some aspects of the survey. The Rural Studies Program is an ambitious effort to develop a more illuminating sociological model of socio-economic change at the village level. In reaching out to and gathering the primary research material, in handling it and interpreting it, the Institute has sought ways of exposing itself to the social realities, ways of avoiding preconcieved models, ways of freeing itself from habits of mind which tend to fit the perceptions into configurations borrowed from foreign contexts. But this can lead to fruitful results only as results accumulate over time, and through the sustained collaborative effort of like-minded researchers and institutions. Another interesting component of the Institute's work is a research-cum-action program in which the studies are linked to certain experimental projects which are implemented in the field. Within this program the Institute has initiated a small farmer project where the economic, financial, technical, social and other problems of self-employment are being studied in the course of establishing a few small

agricultural enterprises in selected areas. By this means, the Institute hopes to provide itself with its own "field laboratory" in which the problems are experienced in their operational reality, and feeds back invaluable data and experience to its research and studies.

Another fact worthy of mention is that, perhaps for the first time for a developing country, the Marga Institute has collaborated with a developed country institute for research into situations in the developed country which are closely linked to crucial problems of our own society. In collaboration with the Institute of Development Studies, Brighton, the Marga Institute is studying the Sri Lanka-U. K. Brain Drain, and the U. K. component of the Sri Lanka tea industry, its ownership, processing, marketing and distribution. These studies are being conducted by two Marga researchers who are collaborating with I. D. S. staff in the U. K.

In general, the Marga Institute has not set itself up as a conventional research institute. It has addressed itself to some of the wider problems of knowledge and its communication in a developing society. The evidence lies in the work already completed by Marga, and readers of these studies can come to their own conclusions. One example is the UNRISD study published under the title "Welfare and Growth." This broad analysis of the social and economic change in our country after independence anticipated the re-appraisal of development strategies which is now taking place in international organizations, many elements of which were foreshadowed in the unconventional nature of Sri Lanka's pattern of growth and income distribution. The studies on "The Needs of Children and Adolescents," and "Low-Cost Housing," pointed towards rural-focused packages of policies which were derived from a fresh approach to local problems and which consciously avoided the conventional urban-oriented programs. These are a few examples from very many others.

The Nature of International Dependence

The preceding description has stressed the independence of the Marga Institute, and especially its autonomous selection and guidance of research projects. But we have, to be sure, depended on foreign sources for much of our funding, and some would say that true independence cannot be achieved in these circumstances. One hears references to the role of assistance to developing countries as an instrument in the power struggle between major power blocs and their economic systems. Undeniably, either "capitalist" or "socialist" assistance can constrict the capacity for self-reliant, free national development; but in situations where resources are sorely needed, external assistance can and has been used very constructively. It is within the capacity of governments and institutes to set the conditions within which external assistance can serve a constructive purpose. If financial assistance is not inconsistent with research independence, then what precisely is the nature of the

captive condition, the subordination that one has in mind when one talks of "academic imperialism"?

The heart of the problem as it relates to social science research lies, I belive, in the intellectual dependence of developing countries on developed countries. The issues with regard to the social sciences have to be placed within an historical context, including the growth of scientific knowledge and the relationships which have evolved between the societies which are more scientifically advanced and those which are less advanced. The structures of knowledge about which we are talking, whether they be in the "pure" sciences (e. g. physics, chemistry) or the applied sciences (e. g. medicine, engineering) or the social sciences (e. g. economics, sociology, management sciences) originated and evolved as an integral part of the technological revolution which occurred in the Western societies. The additions to the stock of knowledge in these sciences, the extension of their frontiers, take place all the time in the knowledge centers of the industrialized countries. It is these centers which command the massive resources of capital and skill to engage in fundamental research and the discovery of new knowledge, and where the demand for new knowledge is immediately felt. There is no question that a great deal of this knowledge needs to be transferred to the scientifically less advanced countries and that these countries will and must continue to draw on the new knowledge that is generated outside their own societies. To that extent they will be "knowledge-dependents" for a long time to come. It would be pointless denying the dependence of developing countries on this stock of knowledge. What is at issue is how the channels can be kept open for the free flow of that knowledge in the forms that are most appropriate.

Transfer processes. When knowledge in the "pure" sciences is transferred to developing countries and acquired and absorbed by them we do not normally hear serious complaints about academic imperialism. It is regarded as a transfer of a stock of knowledge about the physical world and natural phenomena which is more or less universally valid, whether it concerns the structure of matter or the genetic laws that govern plant and animal life. But even here the developing countries have begun to pay more attention to the adaptation of teaching methods and other ways of absorbing this stock of knowledge and making it relevant to their societies.

We get closer to the problem of dependence when we move from the "pure" sciences to the applied sciences and their application in industry and other economic activities. It is here that we can encounter exploitative forms of transfer of knowledge. This is particularly evident when we come to the transfers of knowledge about processes of production which impinge on the commercial interests of the industrialized countries. There are of course different approaches to this

question of technological dependence of the developing countries on the developed, approaches which can contribute in a complementary manner to the growth of self-reliance among developing countries. In one direction, we see efforts of developing countries aimed at eliminating some of the more harmful elements in their technological dependence, best reflected in the recent initiatives taken by UNCTAD. These are directed on the one hand to improving the capability of developing countries to negotiate better terms for the package of modern technology that they acquire, and on the other, to regulating these transfers through an international code of conduct.

In another direction, greater emphasis has been placed on developing technologies which are more appropriate to the Third World countries at their present stage of development because they are less capital intensive, and less in need of components, materials or repair services supplied from overseas. This does not imply a severance of technological links with the more advanced centers, but it seeks to distinguish a different set of pre-conditions needed to create a base for technological growth which will find indigenous roots for self-sustained development.

Academic Relationships. This discussion on technological dependence has its relevance for our concern about academic dependence because it helps us to place our concepts in the global context of the system of scientific knowledge and our dependence on the Western centers within this system. The Third World social scientists who have expressed strong views on the subject have been concerned with several negative features. We will first mention and lay aside some relatively minor grievances of Third World scholars, both real and imagined. Western research scholars are alleged to "mine" data in the Third World and carry it away without making it available to the countries in which they work. The foreign scholars are occasionally said to have "pirated" the work of Third World scholars who had no access to the intellectual centers in the Western world. Where collaborative work is done, the foreign scholar most often remains the dominant partner and due acknowledgement is seldom given to the Third World partners. These problems of course stem from the frictions and career-oriented rivalries within a competitive professional system; within this context, the Western scholars have enjoyed the advantages. These problems of individual scholars may be the least important; but the whole set of academic relationships that stem from this situation enables the Western world of scholarship to accumulate a stock of knowledge about Third World countries, and this in turn enables the Western world to retain the centers and storehouses of knowledge in the Western countries. This could become a vicious circle which effectively perpetuates the condition of intellectual dependence.

What is more important however is whether, and if so how, these

relationships impose intellectual constraints on Third World scholarship, and how they distort the perception of the Third World social realities. One basic factor which lies at the root of the intellectual dependence of developing countries is an education system in which training policies and systems of learning in the developing countries have had to rely heavily on centers of higher learning in the developed countries for the acquisition of advanced skills. Is this a good or a bad thing? The negative features for developing countries have been stated time and again: developing country scholars are trained to think in social and economic contexts very different from those in their own countries. The teacher-pupil relationship persists in a way which insidiously alienates these developing country scholars from their national environment, and induces them to seek approval and acceptance in the Western academic community. Intellectual respectability is gauged with reference to publication in prestigious journals abroad. Intellectual support for the views expressed is invariably sought from foreign scholars. The array of references in the scholarship of developing country academics is most often drawn from the work of Western writers. No doubt some part of this condition can be attributed to intellectual subservience, but that certainly is not the whole of the explanation. The fact is that much of the inquiry into developing country problems has been conducted by social scientists of developed countries. The developed countries have had both the human and financial resources to devote to research, and they have been able to accumulate vast storehouses of information on developing countries in their own centers. Given the historical conditions in which the social sciences developed, it is difficult to imagine how the body of socio-economic knowledge pertaining to developing countries could have grown differently. Then the vital question is: how must social scientists of developing countries relate themselves to that stock of knowledge?

The global distribution of knowledge and technology determine many aspects of the international transfers of skills and "trade" in "brain power." While international intervention through technical assistance programs transfers scarce skills to developing countries, the international market forces set in motion a massive reverse flow of technology in the form of the "brain-drain." The existing structures of learning and dissemination of knowledge are inherently weighted heavily in favor of developed countries, and through the operation of normal market forces in the international employment market they tend to attract some part of the highly trained intelligentsia of developing countries who are an urgently needed resource in their own societies. The deprivation to developing countries also occurs in more subtle ways — ways in which the Western system absorbs to itself the intellectual effort, the modes of thought, the conceptual frames and even part of the highly trained skills, and directs them to goals which have priority in their own societies.

The "outsider" and "insider" in the social sciences

The most important issue raised by Third World scholars is related to the substance and content of knowledge. It has been argued for a long time that the social sciences developed in Western societies in conditions very different from those in developing countries. The academic disciplines in developing countries would therefore have to guard against the uncritical use of methodology, theory and approaches that have been developed by the social sciences in the West. For the understanding of our own social reality we need to develop new tools which reflect the complexities of our own situation. The social sciences rooted in the social and economic reality of Western society tend to provide us with an analytical framework and habits of though which can set up barriers to an understanding of the processes of change and development in developing societies. This position does not need to be argued at length: the underlying criticisms have been generally accepted by scholars both in the developing and developed countries. There has in fact been a very fundamental reappraisal of the conventional approaches to the development problems of developing countries that were current in the fifties and early sixties.

The question that has to be asked here is whether the task of reappraisal and the development of new tools of analysis is a task which has to be undertaken exclusively by the Third World institutes and scholars, and whether the performance of this task implies a certain degree of withdrawal from and severance of links with the centers of knowledge and learning in the more advanced countries of the world. Protagonists of academic self-reliance are not always clear on this issue. Most would probably say that while the task of developing new tools of analysis is not exclusively the prerogative, as it were, of Third World social scientists, it is primarily the task of the Third World; that what is needed is a shift in the present set of relationships in which the centers of social science research into developing country problems are densely located in the developed countries and sparsely distributed in the developing world; that such a shift should aim at locating the main centers of Third World study in the Third World itself.

The Third World scholar would argue that the locational universality which applies in the hard sciences which seek to interpret physical data and natural phenomena has a much more limited application in the social sciences. He would contend that knowledge in social sciences, in that it relates to human behavior, is more specific as well as more variable. For the "outsider" social scientist, the objective study and analysis of various societies is seldom a part of his involvement as in the case of those who live in a society, so that some degree of alienation from his subject matter is inevitable and the probability of misconception is greater. For the Third World scholar, the knowledge he seeks is intimately linked to the problems and priorities in his society which he constantly encounters in the total act of living in it. In the long run this interaction between the academic community and the society in

which they live and participate will determine the relevance and the usefulness of the body of knowledge which social scientists will develop.

The danger in the pursuit of some of the trends of thinking in this discussion is that of intellectual insularity and isolationism. There are several factors that should be recognized when we talk of intellectual self-reliance. First, as mentioned above, the reappraisal of theories and models hitherto employed by the social sciences in the approach to Third World problems has been done by the Western scholars themselves. There are many thinkers in the West who unequivocally subscribe to the basic arguments for our intellectual self-reliance and the revision of old theories. Whether it be the reappraisal of the growth-oriented strategies of development, the emphasis on intermediate technology, the concern with multinational corporations and their relationships with developing countries, it has to be acknowledged that the Western scholars have played a leading role. Failure to recognize this fact would lead to petty forms of intellectual chauvinism and prevent the creative flow of knowledge within the international community as a whole. Second, within the Western system itself there is no single monolithic approach within the social sciences. Those who talk of academic imperialism would in fact rely heavily on the tools of analysis used by scholars in the Marxist tradition. Apart from the Marxist school, there are many other variations and dissents in the Western academic world.

Finally, there is another factor which has entered the situation — the international agencies. Many of them have contributed to a reappraisal of the past strategies and theories of development. The initiatives range from the assault on prevailing approaches to development (Second Development Decade Strategy), the emphasis on anti-poverty rural-focused strategies (World Bank), identification of the links between employment, income distribution and growth (ILO), and restructuring of center-periphery trade relationships (UNCTAD). Of course, any one of these initiatives could be the subject of an interminable debate, and those who argue that what is needed is a radical restructuring of the world economy would tend to devalue these efforts. It would, however, be difficult to deny that they have had a major conceptual impact and introduced new tools of analysis to deal with the problems of development. Intellectual self-reliance therefore requires a clear perception of the total international scene, and the capacity and the intellectual integrity to identify different elements in the international system of knowledge and the heterogeneous international academic community. With this perception, we need to establish our links in a manner which creates the right national conditions, as well as the international framework conducive for the pursuit of social science studies that will be more relevant and meaningful to the Third World.

[Extracted from "Academic Imperialism and Academic Chauvinism: the Two Sides of the Coin," Marga, Vol. 2, No. 4, 1975, pp. 75-95. Colombo, Sri Lanka: The Marga Institute.]

BUILDING MATERIALS

A STONE BLOCK CARVING PLANT
AT JAMSHEDPUR, INDIA
(PHOTO: KAISER ENGINEERS
OVERSEAS CORPORATION)

Ultra-Low Cost Housing

Carnegie-Mellon Working Party

[Over the past two years an interdisciplinary team of architects, engineers, planners and sociologists from Carnegio-Mellon University have developed a method for producing ultra low-cost housing units with local materials and labor skills for use in a variety of disaster relief and rural development situations; this method has been field tested in Bangladesh. The design is an "A" frame modular housing system which can use a wide variety of indigenous materials in a structure which is extremely cheap, labor intensive, easily erected and which is wind and flood resistant.]

Approach

Due to worldwide variations in climate, topography and culture, no universally acceptable housing prototype is possible. Our Working Party decided to concentrate initial efforts in three areas: (1) the development of a building process and methodology which can be applied to a wide variety of situations; (2) the development of a prototype housing unit which could be built throughout large areas of the world with whatever materials were on hand locally; (3) the introduction of technological analysis to improve indigenous building techniques and construction practices of developing countries. All were incorporated into a design program to produce a unit which provides immediate shelter for refugees and, with modifications, can be turned into a long-term house. By concentrating efforts on developing housing for refugees, who are traditionally the people on the lowest rung of the housing ladder, the resulting technologies could be applied to the problem of providing housing for the ultra-low income urban and rural populations in the third world.

An Interdisciplinary Working Party
of the Carnegie-Mellon University,
Pittsburgh, Pennsylvania.

The team decided for a variety of reasons to focus its efforts on developing a prototype for tropical environments. With the large refugee problems in Bangladesh and the low income level of that country, it was considered the best place for the initial work to be done.

Cost: Initially a maximum cost of $10 of shelter space per family was the target. This was thought to be feasible in Bangladesh; but with the price inflation in that country, it was not possible. The objective is now a cost of $10 per occupant. For the design to be acceptable, it has to contain the total cost of materials and labor within this limit. The costs of other items such as sanitary facilities, stabilized soil, drainage ditches and water supply are not included.

Use of Local Materials: Materials indigenous to tropical areas were the only structural materials considered in building the system. The structural flooring and roofing systems were designed so that modification required by material constraints in one system will not affect the details in the other systems. The framing system design for the structure and the connecting materials had to be adaptable to the various structural strengths and sizes possessed by the roof and floor materials. It was the intent of the program to investigate many of the materials available for construction and document the necessary modifications as dictated by material constraints.

Environmental problems: Many environmental conditions impose constraints in the design of refugee shelters. Flooding, wind, and heat of the tropical zone induce extensive loading and design problems. Many areas of the tropics are at an elevation of only a few feet above sea level with a ground water table 9 to 18 inches below the ground surface. During tropical rains, extensive flooding occurs which must be considered in the shelter system design. The high temperature and humidity of the tropical zones necessitate the need for adequate ventilation. The building design must also consider methods for preventing the building material from rotting under the prevalent conditions of heat, rain, and moisture.

Ease of administration: With the vast numbers of people in refugee camps, it is imperative that administrative personnel be able to make frequent checks for illness and death, so that each living space must be adequately lighted and easily accessible. Shelters must also be built to facilitate feeding and medical care for the occupants.

Ease of construction: For a shelter system design to be feasible, a specified number of units must be capable of being produced on a daily basis. Thus, the structural system must utilize a repetitive pattern in the framing so that organized teams with only limited skills can mass-produce the components.

Behavioral constraints: Various behavioral aspects of refugees were defined and related to design constraints. These constraints were then grouped as follows: 1. Stability: In order to reduce emotional stress in the refugee group, the structure should be of a design similar to existing housing types or familiar to the region. 2. Organization: The structure itself had to be designed to be part of an organizational effort, i. e. it had to lend itself to mass production by the refugees themselves. Therefore, the prototype had to be easy to understand, simple to build, and able to utilize pre-fabrication techniques. 3. Involvement: To be able to involve the refugees, the prime constraint was to design a structure that could be built with those tools, materials and building techniques with which rural people in the developing countries would be familiar. If the refugees couldn't use their own tools, in all likelihood the structure wouldn't be built. 4. Environmental improvement: This was the most difficult aspect. Not only would the structure have to be able to reasonably withstand a hostile natural environment, it would also have to withstand a high density refugee camp environment with poor sanitation, health care and other detrimental factors. The structure had to provide a safe sanctuary for families, broken families, and individuals alike, and be flexible enough to allow individual modifications or improvements by the occupants without substantially affecting the strength of the unit.

Description of Structure

The Carnegie-Mellon University Shelter consists of three groups of components: the frame, the floor, and the roof.

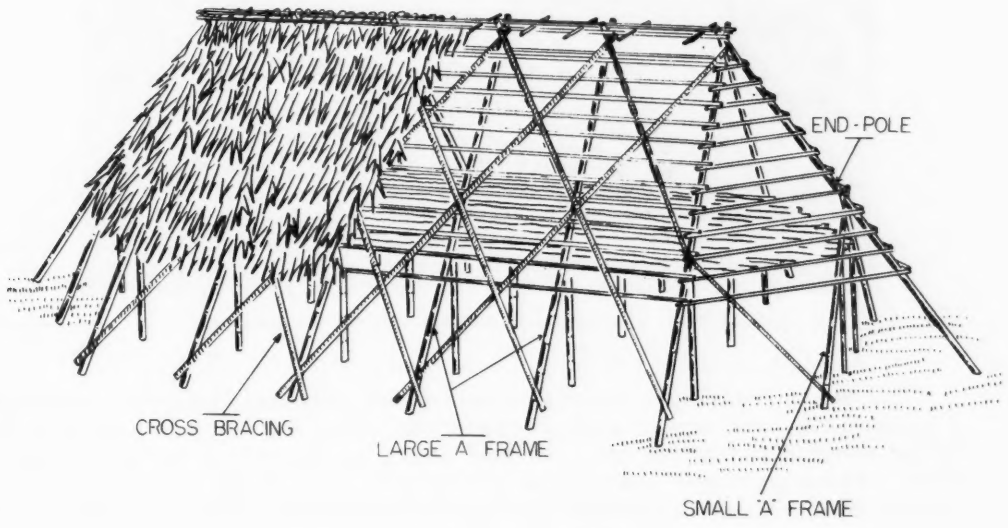

Figure 1: Sketch of Carnegie-Mellon Shelter

Each of these has been designed so it is structurally independent of the others. For example, the frame does not depend on the floor for strength; the floor can be built by itself, before or after construction of the frame; and the roofing material can be any one or combination of materials — either natural, such as thatch, or synthetic, such as corrugated galvanized iron. This enables the structures to be built either one at a time or en masse. The structure is designed so that if initially a short-life material is used for any part of the structure, it can be replaced without having to replace the entire structure.

The shelter can be built to any size the builder desires, either vertically or longitudinally. The ultimate size depends on the number of people who are to occupy the structure; the more people, the larger the structure. It is recommended, however, that the structure not exceed seven normal units in length, nor that it be so high as to be difficult to build with safety. One unique feature of this structure is that the second floor is conceived as having a variety of purposes, but most importantly it is designed to be a refuge from flooding. In an area where flooding is not a hazard, the second floor may be reduced in size (by elevating it higher in the structure) and used only for storage, or eliminated altogether; it can also be used as additional living space.

Figure 2: Photo of a small scale model

The basic framing consists of A-shaped frames, diagonal bracings, a ridge pole, and associated connections. One A-frame consists of two large wooden members notched and bound at the top to form a durable joint. The height and spacing of the frames can be modified when required by the structural strength of the members. The diagonal bracing

between the A-frames is assembled separate from the roofing system. The A-frame was selected as the structural system offering the most versatility. The primary reason for selecting the A-frame is that it is the best shape for resisting wind.

The flooring system consists of the floor and supporting beams and columns, with construction details varying slightly depending on the material properties. The beam-column connections for the flooring do not change but the spacing for the beams and columns vary with material properties. The column height and anchoring system is dependent on the expected local flooding conditions. The roof framing and cover depend on the properties and utilization of the covering material, thus requiring distinct designs for the various covering materials. A means of venting was devised for the vertex of thatched roofs. Openings for doors and windows may be placed where they are needed.

It is felt that the total system is flexible and can be modified to accommodate a variety of material, environmental, administrative, cultural and technical constraints. It incorporates building features which are common to both wood and bamboo structures. The design is simple enough to be built with no more than a machete. It can be built entirely on site, or major components may be prefabricated by work teams and hundreds of units can be built in a day. Finally, the structure is designed to withstand the most severe tropical environment by incorporating such features as an optional second floor to provide temporary escape from flooding while also serving a human function such as providing segregated space within the living unit for members of a single family.

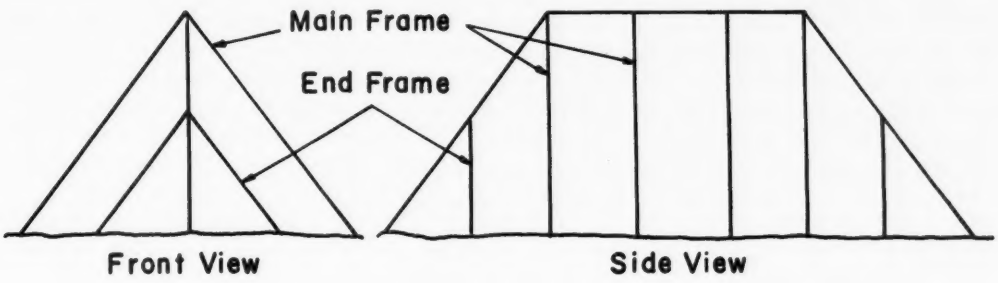

Figure 3 A-Frame Elevation

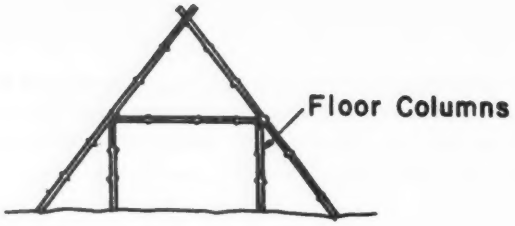

Figure 4 A-Frame Cross Section

Selection of materials. All components of the structure use only indigenous materials which could be produced easily in the immediate region with unsophisticated techniques, or materials common to local use. In 1973-74 the team conducted a series of lab tests on bamboo, and a field test of the structure's adaptability to construction with wood and palm thatch. The field test in Bangladesh tested techniques and procedures for the use of:

A. Frame – bamboo, jute ropes
B. Roof – straw, bamboo and grass thatch
C. Floor – split bamboo poles
D. Binding – jute rope, coconut rope, bamboo withes, or galvanized wire.

Field Tests

These structures have been tested in six locations in Bangladesh: larger numbers in three refugee camps within 20 miles of Dacca, and prototypes for village use in Bandar, Pabna and Comilla. During these tests the problems encountered can be classified as structural problems and cultural problems.

Structural problems: The few problems encountered in the construction process were easily overcome by on-site modifications. However, three distinct problems did arise. The first was that of cost. Prices of materials increased over 500% in four years. Bamboo, while readily available, was much more expensive than our original estimates. As for the roofing material, where grass thatch was available it was well within the cost limitations; but as the grass only has a lifespan of one year, it was only used for short-term or interim structures. In the more permanent structures, such as in Mirpur Bihari Camp, a bamboo mat was constructed; this made the large structures extremely costly ($60-$70) per family unit. By scaling down the structures which did not require a second floor, we were able to put the costs of two-family units back down to the $40 per family category. Future efforts will include attempting to reduce costs further.

The second problem was how best to convey the concept of the

structure to those working on it. The manuals we had prepared proved to be too cumbersome to use in training the work teams, and even literate team leaders ignored them, preferring to explain each step as they went along. We contacted several persons who prepare training aids for the Integrated Rural Development Program health and agricultural projects, and they suggested that the best low-cost media they had found were flip charts.

Another problem concerned roof leakage following the first rains. In most cases this can be solved by lowering the edges of the air vent. In the other cases, it is felt that after several rains the thatch material will "cure" and leakages will stop. The occupants of units built with bamboo shingles at Mirpur have made small adjustments to the roof and virtually all leakage has ended. But in the structures at Pabna and Demra, the thatch is too thin and no underlying mats were used; if mats are installed, the leakage will probably cease.

Cultural acceptability. In June of 1975, Dr. Vijai Singh, a sociologist from the University of Pittsburgh, visited the refugee test sites to evaluate the cultural acceptability of the units several months after occupancy. Concerning the architectural acceptability of the structure, both Bengalis and Biharis expressed their general disapproval because these types of structures were not found in this area, and they were "too tall." Residents of units with elevated second floors, however, had no such complaints. (The popular rural houses here have four walls on the ground with some variation in roofing patterns; most of the brick houses have flat roofs, and others are elevated in the middle.) Many complained about inadequate space inside the structures; most complaints centered on lack of storage and kitchen space. These problems will be worked out for single family units in the coming year, but will remain problems for the multi-family units in the refugee camps. Residents felt that the windows were a little too high and should be lowered so that there is some air flow at the floor level. It is difficult to sleep inside in hot and humid weather. Despite a number of different door styles that were tried, none proved popular and all residents suggested a bigger entrance and a door that can be shut and locked.

The technology used has been consistent with the local technology, and most people can repair their structures without too much difficulty. But despite some of the problems the refugees were facing, Dr. Singh reported a lack of enthusiasm to do something about them on their own. For instance, occupants could elevate the floor of their structures and build drainage around them to alleviate the problem of seepage around the bottom, but they wanted the relief organizations to come and help them. Residents also complained that they did not have any opportunity to express their ideas and preferences

about the structures. They resented the fact that some "local elites" had acted as contact men with the designers, but had little familiarity with the problems facing refugees.

[Extracted from Feasibility Test of an Approach and Prototype for Ultra Low Cost Housing, pp. 1-11, 24-27. A report prepared for the U. S. Agency for International Development, November, 1975. Note: this report includes a detailed construction manual; copies obtainable from AID using reference number TA/OST 75-26.]

Editorial Comment: It would appear that the engineering work behind this design has proved generally successful, that the structures could be built and repaired quickly and easily with familiar tools and materials, and that they were clearly cheaper than conventional houses even when project cost targets were not met in the current inflation. Leaky roofs are not an insoluable problem, but leak-proof roofing will cost more. The question of cultural acceptance, however, is more complicated. Problems of space and ventilation may be manageable, and the unfamiliarity of appearance may diminish over time. If housing for resident villagers rather than refugee camps is being considered, then occupants will have to pay the costs and decide how much space and quality they can afford — unlike refugees who are housed by other peoples' arrangements. Therefore, it would be useful to be able to distinguish elements of strong cultural resistance to this design from the kind of complaining that would be natural in people whose fate had thrown them into refugee camps.

Designing New Low-Cost Roofing for Developing Countries

[This article includes: first, a general survey of the research potential for finding new materials suitable to developing countries; and second, a report on the results to date of a major on-going research project in this field.]

1. RESEARCH OUTLOOK FOR DEVELOPMENT OF NEW LOW-COST ROOFING MATERIALS

Special Advisory Committee to the U. S. National Academy of Sciences. Chairman, Professor Albert G. H. Dietz, Massachusetts Institute of Technology.

More than 80 developing countries suffer from acute housing shortage, principally because of the ever-increasing need for new housing created by expanding populations, as well as the periodic loss of housing from natural disasters. Shortages are most concentrated where the formation of new households and the migration of rural households to places of employment lead to uncontrolled construction surrounding major cities (e. g. Calcutta, Rio de Janeiro, Ibadan). Most such urban housing, and rural housing as well, is poorly constructed, often with scavenged materials, unsanitary, unsafe, and short-lived. Disaster-prone areas need housing that is both safe and capable of high-volume production. But any housing material which is to contribute significantly to relief of housing shortages must be low enough in cost for low income people to pay for it.

The most serious obstacle to low-cost housing in the developing countries, regardless of setting or sophistication, is the lack of a low-cost roofing material that will provide satisfactory performance for a reasonable time under many adverse conditions. An essential component of a dwelling, the roof is critical to shelter, thermal comfort, privacy, and in some

cases is a status symbol, a refuge from floodwaters, a sleeping area, a water-collection system, a storage area. In many developing countries, roofing alone represents more than 50 percent of the total construction cost of a low-cost house.

Usually, roofing for low-cost housing in developing countries is not the product of an organized building industry or process. Most roofs made of low-cost, indigenous materials such as thatch or unfired clay lack durability and can be hazardous to health and safety. The materials often are subject to moisture-induced decay; they harbor vermin and insects and are particularly dangerous during fires, windstorms, earthquakes, and other disasters. To provide more permanent roof coverings, many developing countries expend scarce foreign exchange to import corrugated galvanized iron and other metal roof-covering materials from industrialized countries in the temperate zone. Metal products offer the advantages of being relatively long lasting, salvageable after a disaster, self-supporting over short spans, easily maintainable, and simple to install. In hot climates, however, the heat absorbed by metal roofs converts homes into ovens; where exposed to saltwater spray, ferrous metals corrode quickly. And these materials are often too costly for most of the population and thus do not solve the roofing problem.

Several years ago, the Agency for International Development (AID) requested the National Academy of Sciences to review the practicality of a major research effort to develop new solutions to roofing problems in developing countries. The Academy's Building Research Advisory Board appointed a special advisory committee of individuals with special knowledge of the technical, social, economic, and manufacturing aspects of roofing in developing countries. Two members of the committee were directors of housing research from developing countries.

The committee reviewed past and current research and development (R&D) activities directed at solving particular roofing problems of developing countries, as well as more general roofing R&D in other countries throughout the world. The committee found that most such R&D deals with the problems associated with roofing materials now in common use, or aims at improving a specific material or product. Although none of the current R&D activities reviewed demonstrates immediate solutions to the roofing problem, work is being conducted on materials currently used for roofing (such as thatch, CGI, aluminum, and clay) and an extensive literature already exists on these materials. The committee decided, therefore, to explore the feasibility of developing new low-cost products and processes with potential for providing roofing materials that offer better performance than those most commonly used today. This report presents the committee's conclusions and recommendations concerning areas of research and kinds of materials indicating significant potential for the development of new roofing technologies that could provide early solution to the particular problems of developing countries.

Conclusions

1.) The introduction of high-performance roofing systems that are low in cost and capable of adaptation to satisfy local social-acceptance requirements, could, of itself, significantly accelerate production of more and better housing. Furthermore, research directed toward development of fresh approaches to roofing problems in developing countries is likely to be productive at this time: in polymer (i. e. plastic) science, in innovative applications of cement and asphalt, and in the improved use of indigenous vegetable, animal, and mineral products, the committee members found sufficient unrealized potential to convince them that, given adequate research funding, new solutions can be found.

2.) Searches for low-cost materials or systems embodying desirable characteristics should include composites containing a reinforcement, a filler, and a coating, all of which are held together by a "binder." Reinforcement gives strength to the composite material; a filler gives bulk; and a coating gives protection to the surface against weather. These may all be found together in a single material, as in galvanized iron. But when new combinations of materials are sought, and existing materials are in need of strength or surface protection or low cost bulk supplied by others, then a binder is needed to "glue" together the separate components. The binder material may also add surface protection or strength to the materials with which it is combined.

3.) Insofar as possible, local products should be utilized for each component of a composite. For example, vegetable fibers, rock wool, glass fiber, and wire mesh ought to be considered for reinforcement; soil, waste glass, rock, and sawdust ought to be considered for fillers; and paint, whitewash, and sand sprinklings ought to be considered for coatings. It appears that potential reinforcement, filler, and coating materials are available in most of the developing countries, but that suitable binders to hold them together generally are not. If suitable binders can be developed, and simple, low-cost methods can be devised to use them in the manufacture of composites, such composites might well provide the versatility required to meet local needs in widely differing developing regions.

4.) To the fullest extent possible, R&D in roofing technology ought to be conducted within the developing countries, even if the cooperation of institutions of more developed countries must be sought. Research and design specialists living in developing countries will be more cognizant of available resources and the design requirements peculiar to their localities, and new roofing technologies generated within a country should be more easily diffused among and accepted by the local population.

Categories of Materials for Use in Roofing Composites

During its investigation, the committee identified a wide variety of materials that researchers could consider in a search for new roofing systems for developing countries. Since developing countries differ so widely in their needs, climates, and available materials and resources, each must determine independently which combinations are most promising. The committee believes, however, that an organized, systematic approach to the establishment and direction of R&D programs could lead to early results for use in a variety of countries.

Plastics for binders. Since binders are generally the missing indigenous element in composite materials, and given the versatility of plastics, these were thought to have an important role in the development of new combinations of materials. By chemical definition, plastics (also known as polymers) are synthetic, chainlike molecules of high molecular weight that are the end result of the chemical binding of large numbers of smaller molecules known as monomers. Today there are approximately 40 families of plastics. Each plastic has a well-defined combination of properties, processing requirements, and economics that make it uniquely applicable in certain situations and unusable in others. In developing countries, plastic resins (i. e. plastic materials prior to mixing) could, in principle, be combined with locally available reinforcement and fillers by local labor using low-cost equipment to form roofing sheets that could substitute for currently used corrugated metal sheets.

With over 40 families of plastics available and hundreds of variables possible within each, determining the balance of properties required in the end use becomes most important. Today, polymers can be tailored to produce bulk fiber, foam, film, coating, and adhesive plastics that may be hard or soft, rigid or flexible, rubbery or leathery, and porous or nonporous. Some of the physical considerations that must be considered are the end-product requirements for the following characteristics: strength and rigidity, moisture resistance, temperature range appropriate to local conditions, low purchase cost, and low cost for processing into composites. The rating of physical requirements could be assigned ranges (e. g. tensile strength: 4,218 tons/m^2 or 6,000 psi, essential; above 5,624 tons/m^2 or 8,000 psi, desirable). Choosing the best plastic for a specific job then becomes a matter of finding the one material that best combines the necessary and desirable properties per unit cost.

Plastics are differentiated as either thermoplastic or thermosetting. Thermoplastic resins require heat to form plastics, and the final plastic can be remolded a number of times without loss of properties simply by applying more heat. Thermoplastic scrap can be reclaimed and reprocessed without difficulty. Chemically, the plastics they produce are linear molecular chains that fuse and solidify without serious chain

breakage and without much cross-linking. Polyethylene, polystyrene, polyvinyl chloride, cellulosics, and nylon are examples of thermoplastic resins. A thermosetting resin forms a plastic with a permanent shape that cannot be altered reversibly when heated. The final plastic after setting is a cross-linked, intractable, nonflowing material. Typical plastics in this family are polyesters, phenolics, and ureas. Certain thermosetting resins require no heat and little or no pressure to form their final shape. Among these are some specific polyesters, epoxies, silicones, and polyurethanes.

The technology of fabricating building products using plastics with other materials is highly developed and well documented. If some plastic is compatible and blends with some local material, the composite could be made into many shapes and sizes to meet local tastes. The major challenge to research is to find inexpensive composites that will resist moisture, ultra-violet light, insects and fungi; resistance to fire must also be considered in the interest of safety.

Sulfur should be given serious consideration as a material for binding mixtures of other indigenous materials, as a valuable coating and joint-grouting material, and as a material from which small-size roofing products, such as tiles, can be made. Although sulfur has not been widely used as a building material, its full potential as a binder for use in low-cost roofing for developing countries should be explored. Only in the last decade has the use of this material for construction purposes been subjected to comprehensive scientific investigation. Its use in developing countries is particularly worth consideration because many have abundant supplies of sulfur as a result of volcanic activity and as a by-product of oil refining. Sulfur also could prove to be an inexpensive import item for countries lacking an indigenous supply.

Previous research and testing have been directed primarily toward the use of sulfur in sulfur-concrete and as a surface bonding agent. Elemental sulfur is a bonding agent with unique properties: it becomes molten at 240°F, only slightly higher than the boiling point of water; it is insoluble in water and demonstrates qualities of water impermeability; it is odorless, non-toxic in normal use, and a poor conductor of heat; it has an indefinite storage life; and it can be reprocessed. All these features indicate excellent potential for use in developing countries as a roofing material.

Elemental sulfur is particularly suitable for labor-intensive construction methods, but does have certain limitations: it is flammable; and it must be converted to a liquid state before aggregates or fillers can be added. Product developers and users must also be aware of

the possible release of sulfuric acid in the presence of moisture and the potentially harmful effects of ingestion. Advantages seem to outweigh the disadvantages, however, and a concerted R&D effort is warranted at this time.

Agricultural and Wood Wastes. Locally available wood wastes and agricultural wastes could be used for a variety of reinforcement and filler materials. Research to develop roofing materials for low-cost dwellings might also concentrate on one or more of the chemicals present in wood and agricultural wastes that could serve as binders.

Prime candidates are lignin and furfural. Lignin is a major ingredient in higher plants, where it binds together cellulose fibers to form the rigid woody structure. The lignin content of some plant materials that are widely available in most countries is shown in Table 1. Furfural, too, is widely available from most agricultural wastes, which are used even in industrialized countries for the production of commercial furfural. The furfural content of some representative vegetable materials is also shown in Table 1. Considerable data are available on the use of lignin as a binder in plastics and laminated boards, as well as for its use with phenolic resins, a combination which is claimed to be suitable as a wood particle-board binder. Furfural also is used as an ingredient in industrial resin, especially the phenol-aldehyde type. Furthermore, it itself reacts readily with lignin, and, in the USSR, a lignin-furfural resin has been developed and used as a binder for molded wood products with encouraging results. Research to explore using lignins alone or combined with furfural as binding agents in a particle-board type of roofing panel could be productive at this time; both binders could be produced from inexpensive waste materials already available in developing countries.

TABLE I : CHEMICALS WITH POTENTIAL USE AS BINDERS

Lignin Content of Some Plant Materials		Furfural Content of Miscellaneous Agricultural Wastes	
Plant Material	% Lignin Content	Waste Material	% Furfural Content
Wood	24 to 28	Corncobs	22.0
Bamboo	29 to 35	Cottonseed hull brand	20.0
Rice hulls	40.0	Cornstalks	16.5
Peanut shells	28.0	Bagasse	17.0
Bagasse	20.3	Rice hulls	12.0
Coconut shells	31.9	Peanut hulls	12.0
Corncobs	30.4		

Source: Based on data from Encyclopedia of Chemical Technology, 2nd ed. Vol. 12. 1967, (New York: John Wiley and Sons) and Vol. 10, 1966.

Building panels have been manufactured from agricultural and wood wastes for a number of years, and the following three general types are commercially available: hardboard, insulation board, and particle board (chipboard). Hardboard panels, such as Masonite, have excellent physical properties and have been used in some instances for the exteriors of housing in developed countries. Their ingredients can be cheaper than those of particle board, since a synthetic resin binder is not required. Hardboard, however, is usually pressed from wood fibers prepared by either the Masonite or Asplund processes, both of which require wood chipping, softening, defibrillating, and wet-sheet forming operations prior to panel pressing. Together these make a complex and costly process requiring, for developing countries, a high investment in equipment and plants. As a result, hardboard is not now manufactured in most developing countries, and is an imported item even though suitable ingredients may be available locally. If lower cost processing can be achieved this might be changed.

The other two products, insulation boards and particle boards, have good physical characteristics and, with chemical additives, can be made resistant to fungus and insects. Particle boards have been made successfully from a variety of agricultural wastes as well as, more conventionally, from wood chips. The process is relatively simple, and particle board is now manufactured in some developing areas (e. g. Central America). The cost of these locally produced panels, however, is too high for it to be an ideal construction material for low-cost housing in developing areas. A major contributor to this cost is the synthetic-resin binder of petrochemical origin. In Central America a particle-board panel made from wood chips measuring 4 ft wide by 8 ft long and 1 1/2 in. thick sells for $0. 35 per square foot, and it is estimated that the resin binder represents over 50 percent of the total material cost in the manufacture of particle board. [Note: This was before the 1974 rise in petrochemical prices.] These figures suggest strongly that a building panel suitable for developing countries could be developed if costs could be reduced, that is, if the need for an imported synthetic resin binder could be eliminated from the particle board manufacturing requirements. Additives to enhance insect and fungus resistance will also be needed in many tropical areas; but conventional chemicals now used for these purposes may prove adequate.

Concrete. An analytical and laboratory testing program should be undertaken to develop more appropriate and economical reinforced concrete products. The research effort should focus on the use of reinforcing materials such as wire mesh, locally available chopped wire, glass fibers, rock wool, and various vegetable products such as bamboo, bark, and wood fiber (wood-fiber concrete is known as "wood wool" in some parts of the world).

[Extracted from Roofing in Developing Countries, pp. 1-7, 10-12, 14-16, 41-43. Washington, D. C. : The National Academy of Sciences, 1974.]

2. ROOFING MATERIALS DEVELOPMENT

Monsanto Research Corporation, Dayton, Ohio

The following report summarizes the findings to date of the Monsanto Research Corporation working under a contract with the U. S. Agency for International Development (AID) for development of new low-cost composite roofing materials for use in developing countries. The stages of the work which have already been completed include: (a) establishing generalized criteria for roofing, (b) defining composite material ingredients through a screening process, (c) defining the most promising sets of materials and processes based on the performance of the products generated, and (d) analyzing on a preliminary basis the cost and practicality of a few of the most promising products. Preparatory work has begun for testing the materials and introducing their manufacture in three countries — the Philippines, Ghana, and Jamaica. Final stages of this project will include material optimization, design, fabrication, field manufacture, and final evaluation including cost determination.

Roof Criteria

A set of criteria for roofs was established that included generalized requirements and also those necessarily due to the specific objectives of AID for their use in developing countries. Three categories of criteria were used. These included: Requirements (must be achieved); Desirable Characteristics (desirable but not necessary); and Highly Desirable Characteristics (to be emphasized due to specific AID objectives). It was found necessary to establish criteria for a roof, rather than just for a roofing material. Taken into consideration were the roofing material itself, architectural design, construction and detailing, economics, and sociological factors. Only roofing for relatively small, single-storey houses was considered.

The "required" and "highly desirable" characteristics are listed in Table 1. The "required" characteristics are not weighted, since they are all necessary conditions. The "highly desirable" characteristics are given weights based on criticality of performance, the degree of emphasis suggested by AID personnel, and the consequences of achieving these characteristics based on the designated approach, i. e. the inevitable trade-offs among desired qualities. Numerous additional desirable characteristics (not listed here) were also selected, in terms of mechanical, environmental, optical, social, thermal, and acoustic properties. These were weighted in a manner similar to the highly desirable characteristics.

Screening of Material Ingredients

Fillers. Material ingredients were selected through a screening process to provide the basis for composite material and process development. The criteria for selection of the filler materials included seven categories:

TABLE 1

CRITERIA FOR ROOFS

Requirements	Highly Desirable Characteristics	Weight
Keep off rain	Low cost	9
Not leak	Indigenous Material (over 50%)	9
Water resistant	Acceptability to:	
Wind resistant	User	8
Adequate strength	Government	8
Keep out direct sun	Fire resistance	5
Adequate life (3 years)	Easy installation	5
Available materials	Labor intensive manufacture	6
	Reasonable life (5 years)	6

source, availability, form, cost, mechanical performance, life and compatibility. In the first year of the project, a wide screening was conducted using source, availability, form, and cost as criteria. A host of fillers passed this initial screening, but just a few indigenous binders were deemed worthy of more detailed analysis. In the second year about 20 fillers were examined that were considered representative of those found to be widely available in participating countries. These included such materials as bagasse (residue from sugar cane), sawdust, wood shavings, bamboo, coconut husks, rice straw, ore tailings, clay, palm fronds, and water hyacinths.

These fillers were then tested as a primary constituent (70% of volume) of a composite with a polystyrene thermoplastic binder. All were prepared identically in a melt process using an intensive shear mixer (Banbury machine). Characterization included measurement of flexural and tensile strength and modulus (rigidity), both initially and following 1000-hour exposure in a carbon-arc weatherometer (which subjects materials to controlled cyclic water, humidity, and temperature changes). Results of this initial examination are listed in Table 2 in terms of the initial and retained tensile strength of a few representative filler materials. Bagasse and sawdust performed the best, as illustrated by their retention of initial properties after 1000-hour weatherometer exposure. (The relatively low retained strengths indicated in the table are partially attributable to the use of unstabilized polystyrene for accelerated screening. These results are not necessarily indicative of the properties of the materials combined with other ingredients.)

Importantly, it was noted in the screening that the humidity and thermal cycling conditions caused the most rapid degradation of the highly filled composites. The ability of bagasse and sawdust to resist

TABLE 2

SUMMARY OF TYPICAL RESULTS OF EFFECT OF FILLER ON TENSILE STRENGTH OF COMPOSITE PANELS[a]

Filler[b]	Tensile Strength, psi[c] Initial	After 1000 hr Exposure[d]	Strength Retained %
Bagasse	3400	1650	49
Sawdust	3700	1400	38
Bamboo	2000	0	0
Coconut Husks	3050	250	8
Rice Straw	2250	250	11
None[e]	3450	1000	29

(a) Based on 70 vol % filler in polystyrene. Processed in Banbury using whole filler. Compression molded panels ~9 in. x 9 in. x 1/8 in. Specimens milled from panel.
(b) Only processing of filler was Banbury mixing in presence of polystyrene, except for drying of green plants.
(c) ASTM D638 - tensile, rate 0.05 in./min.
(d) Tensile strength following 1000 hour exposure in Atlas weatherometer with cyclic UV, water spray, temperature, humidity.
(e) Polystyrene panels with no filler added.

degradation from simulated rain and temperature change was impressive. The rapid temperature/humidity degradation contrasted with the milder effects of ultraviolet radiation, elevated temperatures, or just constant high humidities. Bagasse was selected as the best candidate filler, with sawdust providing a good alternative when available. Whole bagasse, which included at least 20% pith, was used in this evaluation.

Binders were placed in three categories: (a) thermoplastics, (b) thermosets, and (c) others. As with the fillers, extensive screening was

conducted in the first year based on binder source, availability, form, and cost. Additional study in the second year included screening for mechanical performance, life, and compatibility. The binders examined were as follows: Thermoplastics included styrenics, olefins, and PVC. Thermosets comprised polyesters, phenolics, and melamine/formaldehyde. The "other" binders encompassed natural rubber, polyelectrolytes, water-glass (sodium silicate), and naturally occurring aldehyde monomers (derived from pentosans in bagasse). The screening and selection process was severely complicated by the sharp rise in prices of petrochemicals and its effect on synthetic binder costs during 1974-1975. Reconsideration of 1973 cost analyses was necessary: the general effect was that the previously low cost resins containing minor amounts of expensive modifiers increased in price to a much greater extent than did the higher cost engineering plastics.

The binders were screened quantitatively through measurement of their initial and retained physical properties, and qualitatively through their processability and compatibility. Typical performance of a few binders in combination with bagasse is illustrated in Table 3 for the styrenics and a sulfur-cured natural rubber. The relative performance of these binders is best illustrated by their retention of strength following 1000 hours exposure in a weatherometer. The excellent performance of the styrene/acrylonitrile (SAN), acrylonitrile/butadiene/styrene (ABS) and the cured, stabilized rubber is shown relative to the poor properties of polystyrene. (Polystyrene durability could be improved by the addition of stabilizers, UV screeners, etc., but at increasing cost.) The binders selected from the screening were SAN, ABS, polyvinyl chloride (PVC), phenol/formaldehyde (P/F), polyelectrolytes, and natural rubber. The olefins, polystyrene, polyesters, sodium silicate, and in situ generated furfuraldehyde monomer were all deemed inadequate for a variety of reasons.

The best three binders were SAN among thermoplastics, P/F among thermoset plastics, and natural rubber among non-plastics. The SAN was highly attractive from its well-known stability characteristics and its demonstrated mechanical performance in conjunction with bagasse. In this highly filled system it lacked sufficient toughness for nailability, but this was deemed to have a lower priority than other factors. (A specially plasticized and stabilized PVC formulation was later added to this category. PVC is manufactured locally in the Philippines, and in that country a modified PVC-bagasse composition may offer an attractive combination of toughness, fire resistance and good outdoor aging.) Phenol/formaldehyde (P/F) has been used successfully for many years as a resin binder in a variety of exterior applications. This, combined with its performance in combination with bagasse and its very low cost, contributed most to this resin's acceptability. Natural rubber was also highly attractive since

TABLE 3

SUMMARY OF TENSILE STRENGTH PROPERTIES OF VARIOUS THERMOPLASTIC BINDERS AND NATURAL RUBBER FILLED WITH WHOLE BAGASSE

Binder[a]	Tensile Strength, psi		Percent Strength Retention
	Initial	Following 1000 hr[b] Accelerated Exposure	
Styrene Acrylonitrile (SAN)	4000	3900	98
Acrylonitrile Butadiene Styrene (ABS)	4200	4200	100
General Purpose Polystyrene	3400	1650	49
Cured Natural Rubber	3000	2950	98

(a) 70 vol % bagasse filler; no stabilizers or pigments added except in the natural rubber formulation (Flectol H and Mapico #477)
(b) Cycle: 1 hr water spray, 3.8 hr carbon arc UV

it offered the potential of providing the base for a 100% indigenous roof. Natural rubber is not usually known for its long-term stability, but this can be improved with stabilizers and fillers. It has remained low in cost during the last few years, giving it an unexpected cost advantage. Some of the other binders tested could perhaps be viable in developing a composite roofing material, but they were considered to be less effective. They may need to be examined further in the future.

Primary Candidate Composite Materials and Processes for Roofing

Using the ingredients selected through the screening process, sets of composite materials were optimized with respect to process and formulation for local manufacture. Four categories of composite materials were defined, having as a prime distinction the nature of the process, and secondarily the binder or the filler. In all cases, bagasse was considered as the primary filler, but sawdust could be substituted. Each category of material was processable with available equipment, with potential latitude for alternative binders. All these roofing materials would be applicable to thin corrugated roofing panel designs.

The four categories of materials are:

I Melt-compounded, thermoplastic, resin-bonded, bagasse-fiber-reinforced composites;

II Wet or dry-blended, thermoset resin-bonded, bagasse-fiber-reinforced composites;

III Wet-process, thermoset resin-bonded, depithed-fibrillated-oriented-bagasse fiber-reinforced composites;

IV Wet or dry-blended, resin-bonded, unfired clay tiles.

Category I materials are highly attractive because of their excellent initial and retained properties, their ready formability into a variety of shapes, and the simplicity of the manufacturing process which requires no pretreatment of whole bagasse (as received from a sugar mill). The chief disadvantage is the need for a specific type of intensive shear mixer (e. g. a Banbury), which requires significant capital. (Banbury machines are readily available in countries where rubber is processed on any scale.) Importantly, however, the only necessary equipment is this mixer and a corrugated sheet-forming apparatus; the sheet forming requirement is inherent in all four categories of materials.

The primary advantage of the Category II materials is the simplicity of the process both in terms of equipment requirements and number of operations. Grinding of bagasse and separation (not removal) of pith is first necessary. Then, the bagasse is simply wet or dry-blended with a thermosetting resin, and compression-molded into a sheet. This process is by far the simplest of all the four systems. The fact that a thermo-

setting resin is used limits reprocessability of the material, but this is not a major detriment. As with the other processes, compression molding at temperatures around 300°F and pressures of 500 psi (pounds per square inch) is required.

The Category III product probably has the greatest potential since the binder requirement is the lowest of any of the four. The resin requirement is less than 10% (potentially 3-5%) of the composite system. This results in at least 90% of the composite, by either volume or weight, being indigenous bagasse. The properties of this system are outstanding, considering that it is primarily bagasse. These properties are achieved by using highly processed bagasse fibers (from which all pith has been removed), orienting these fibers into a mat, and binding them with a thermosetting resin. Advantageously, the process is applicable to both very small and large scale manufacturing while maintaining reasonable economics. The disadvantages of the process are the requirements for significant processing of the bagasse, large volumes of process water, and associated capital equipment.

Category IV materials include a large amount of clay. Their advantage is in geographic areas where clay is readily available and where technology for working with clay exists. The toughness of the product is less than that of the other three categories of materials, which contain a large amount of bagasse, but this limitation can be overcome through panel and roof design. The process involves very simple wet or dry blending much like that presently used in making clay bricks or cement. An advantage is that no firing is required, although heating to around 300°F at pressures of 500 psi are necessary.

Cost and Practicality of the Four Composite Roofing Material Candidates

The material costs for the four categories of composites are shown in Table 4 (based on 1975 material costs in the participating developing countries). Category I, II, and III materials all met the target of less than 10¢ per square foot (for materials alone). That is, they have a potential for costing less than corrugated galvanized iron but with acceptable performance. Of particular interest is the Category III material, which contains only 3¢/sq ft of ingredients. It is expected that up to 5¢/sq ft will need to be added to this material to provide waterproofing, but the good economics of this system will be retained if processing costs can be kept under 10¢ per square foot. All material cost data (¢/sq ft) are based on an anticipated panel-type roofing material that is expected to have thickness of about 0.1 inch. This thickness allows comparable performance to the corrugated iron or aluminum commonly used for roofing in low-cost housing.

The capital requirements for the Category I and III materials are about the same and provide for the necessary high degree of processing of the bagasse fiber. The capital requirements for Category II and IV materials

would be identical and relatively low. At this point, only these qualitative statements may be made about the processes, all of which are quite practical for a variety of sizes of manufacturing operation, including village-level industries. Their actual costs under developing country conditions will be explored further in the coming year.

TABLE 4

SUMMARY OF INGREDIENT COSTS FOR THE CANDIDATE ROOFING MATERIALS

Category	Title	Material Cost[a] U.S. ¢/lb	Material Cost[a] U.S. ¢/sq ft
I	Melt-Compounded, Resin-Bonded, Bagasse-Fiber Reinforced Composites	12-18	8-12
II	Wet or Dry Blended, Thermoset-Resin Bonded, Bagasse-Fiber Reinforced Composites	14	10
III	Wet Process, TS Resin Bonded, Depithed Fibrillated Oriented Bagasse Fiber Reinforced Composites	4	3
IV	Wet or Dry Blended, Resin Bonded, Unfired Clay Tiles	8	12
-	Target Properties 1975[b] (cost of corrugated galvanized iron sheets)	-	<11

(a) Includes no processing, handling, administrative, or profit costs Best estimate of ingredient costs in participating countries (U.S. $).
(b) Adjusted from 1974 figure of 8¢/ft^2 which was based on 1/3 the cost of corrugated galvanized iron sheet.

[Extracted from Development of Low-Cost Roofing from Indigenous Materials in Developing Nations, pp. 15-39. Second annual report prepared by the Monsanto Research Corporation for its contractor, the U. S. Agency for International Development, on the progress of the project as of September, 1975.]

Ferrocement

U. S. National Academy of Science

[Ferrocement, i. e. thin cement sheets built around chicken wire, has qualities of strength, low cost and adaptability which have only recently been recognized despite widespread use of other forms of reinforced concrete. It has many potential uses, notably for crop storage, that are only now being explored.]

Ferrocement is a form of reinforced concrete. Its reinforcement consists of closely spaced, multiple layers of steel mesh completely impregnated with cement mortar. Ferrocement can be formed into thin sections less than 1 inch thick, with only a fraction of an inch of cover over the outermost mesh layer. Conventional concrete is cast into sections several inches or a foot thick with an inch or more of concrete cover over the outermost steel rods. Ferrocement reinforcing can be assembled over a light framework into the final desired shape and mortared directly in place with a thick mortar paste, while conventional concrete must be cast into forms.

Thin panels of ferrocement can be designed to levels of strain or deformation, with complete structural integrity and water tightness, far beyond limits that would render conventional concrete useless. Ease of fabrication makes it possible to form compound shapes with simple techniques; with inexpensive materials; and, if necessary, unskilled (but supervised) labor.

History of Ferrocement

The most extensively used building medium in the world today is concrete and steel combined to make reinforced concrete; familiar uses are in high-rise buildings, highway bridges, and roadways. Yet, the first example known of reinforced concrete was a ferrocement boat. Joseph-Louis Lambot's original

French patents on wire-reinforced boats were issued in 1847 not long after the development of portland cement. This was the birth of reinforced concrete, but subsequent development differed from Lambot's concept. The technology of the period could not accommodate the time and effort needed to make mesh of thousands of wires. Instead, large rods were used to make what is now called standard reinforced concrete, and the concept of ferrocement was almost forgotten for a hundred years. Reinforced concrete for boatbuilding reappeared briefly during the First World War, when a shortage of steel plates forced a search for other boatbuilding materials. The U. S. and U. K. governments, among others, commissioned shipbuilders to construct seagoing concrete ships and barges, some of which continued in use after the war. The same phenomenon occurred in the United States during the Second World War, but the vessels were less practical to operate than lighter wood or steel ships.

In the early 1940s, Pier Luigi Nervi resurrected the original ferrocement concept when he observed that reinforcing concrete with layers of wire mesh produced a material possessing the mechanical characteristics of an approximately homogenous material and capable of resisting high impact. Thin slabs of concrete reinforced in this manner proved to be flexible, elastic, and exceptionally strong. After the Second World War, Nervi demonstrated the utility of ferrocement as a boatbuilding material. His firm built the 165 ton motor sailer Irene with a ferrocement hull 1. 4 inches (3. 6 cms) thick, weighing 5 percent less than a comparable wood hull, and costing 40 percent less. The Irene proved entirely seaworthy, surviving two serious accidents. Other than simple replastering necessitated by the accidents, the hull required little maintenance.

FIGURE 1: Built in 1887, this Dutch ferrocement boat was still afloat in 1967 at the Amsterdam Zoo.

The emphasis on boatbuilding has obscured Nervi's noteworthy applications of ferrocement to buildings, begun in 1947. After building a small storage building in his own construction yard to demonstrate its versatility and strength, he covered the swimming pool at the Italian Naval Academy with a 50-foot vault and followed this with the famous Turin Exhibition Hall — a structure spanning 300 feet. He subsequently built several other long-span structures of ferrocement.

Characteristics of Ferrocement

Ferrocement is a high-quality structural material whose simple constituents and formation make it usable for many construction purposes in even the most underdeveloped societies. Ferrocement making usually uses a freestanding frame of wire mesh that is mortared in place on site. The wire mesh is formed into the desired shape, which may be flat or shaped into domes or curves. Supporting framework used to outline the shape can be of wood or other convenient material.

The economy of ferrocement construction, compared with steel, wood, or glass-fiber reinforced plastic (FRP), depends greatly on the product being built; but ferrocement is almost always competitive, particularly in tropical developing countries where steel is expensive, frequently needs foreign exchange and requires sophisticated facilities and skilled operators. FRP is much more costly, creates a fire hazard, requires advanced technology, sophisticated materials, and skilled labor; and its ingredients are sensitive to tropical temperatures. Wood is almost nonexistent in many countries. Even heavily forested countries such as Indonesia, the Philippines, and Thailand foresee serious shortages and in the tropics wood is subject to rot, insects, and teredos. The relatively low unit

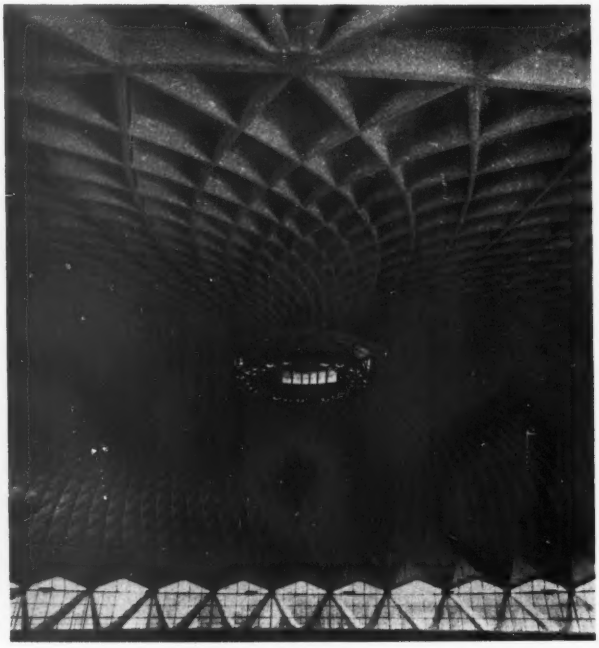

FIGURE 2: Nervi's Pallazetto dello Sport in Rome. The ferrocement precast elements form the structure and shuttering to the cast-in-situ ribs and topping.

cost of materials may be the greatest virtue of ferrocement. Worldwide, the costs of sand, cement, and wire mesh vary somewhat, but the greatest variable in construction costs is the unit cost of labor.

Suitability to Developing Countries

Ferrocement may be fabricated into almost any conceivable form to meet the particular requirements of the user. This is particularly pertinent where acceptance of new materials may be dependent on their ability to reproduce traditional designs. The basic raw materials for the construction of ferrocement — sand, cement, and reinforcing mesh — are readily available in most countries. Sand and cement are used in building and road construction, and mesh is used in agriculture (chicken netting) and housing construction (plastering lath). Except for highly stressed or critical structures such as deep-water vessels, adequate ferrocement construction does not demand stringent specifications. A wide range of meshes can be used; both hexagonal and square meshes have produced successful structures. The cement is of a standard quality used in building construction, and special grades are unnecessary.

Little new training is required for the laborers, providing a skilled supervisor is on hand. Cement construction techniques are widely known in developing countries, and indigenous construction workers often show a good aptitude for plastering. Ferrocement construction simplifies transportation, logistics, and materials-handling problems in developing countries. Sand and water can usually be obtained in the

FIGURE 3: A paste of mortar is forced into the layers of mesh by hand.

FIGURE 4: Or mortar can be put in by trowel. The mortar is dry enough to remain in place when applied; a formwork is not needed.

region of the building site; and the quantity of cement normally required can be easily transported. Only the wire mesh may require transportation from distant production centers. Under extremely difficult conditions (such as in the roadless highlands of Nepal), wire mesh may be hand-loomed on site from reels of straight wire, a technique apparently already in use in rural areas of the People's Republic of China. For simple, indigenous-type agricultural or construction uses, no well-developed or centralized building site is required. Construction can well be done on site at the riverbank, in the village, high in the mountains, or wherever needed.

Food-Storage Facilities

The problem of food storage in the developing countries is emerging as a major subject of attention. Increasing supplies of food grains, such as rice, wheat, and maize, resulting from the Green Revolution, for example, have caused an unprecedented need for grain storage where production areas are still unprepared to store this new abundance adequately. Figures in the order of 25 percent indicate how much grain is lost due to inadequate storage facilities and practices. Facilities are also needed to protect any products sensitive to temperature, humidity, rain, wind, pest animals, bacteria, or fungi. Other typical products requiring storage are peas and beans, oil crops such as peanuts and soybeans, salt, drinking water, and nonfood items such as fertilizers, pesticides, and cement. Major needs are for small-scale silos, particularly for on-farm storage.

A particular advantage of ferrocement in building food-storage facilities in developing countries is its adaptability to an almost unlimited range of curved shapes and local conditions. Ferrocement silos require little maintenance, and they offer protection against rodents, birds,

insects, water, and weather. Ferrocement is watertight and, with appropriate sealants, it can also become airtight. In an airtight ferrocement bin, respiration of grain, or similar products, quickly removes oxygen from the atmosphere inside and replaces it with carbon dioxide. Any insects or aerobic microorganisms present cannot survive to damage the stored product. No fumigation is needed. Hermetic storage of this kind is particularly suitable in the tropics for the storage of dry grain.

Silos in Thailand. A family of cheap, airtight bins made of ferrocement, the Thai silos are sized to hold 4-10 tons of grain, other foodstuffs (e. g. peanuts, soybeans), salt, fertilizer, pesticide, cement, or 2,000-5,000 gallons of drinking water. The silos were developed over the past 4 years by a government corporation in Thailand to fit requirements of the developing world. The designs are versatile, and the storage units can be built on extremely adverse sites: where the water table is at the soil surface, or in remote areas where even vehicular access is impossible. These bins require no maintenance, are easily padlocked against thieves, and protect against water, rodents, birds, insects, aerobic micro-organisms, weather, and serious loss of seed germinability.

The base of the silo is saucer shaped and, where necessary, is built on an earth pile to raise it above the water table. This gives a strong, easily constructed structure that can resist foundation failure. It consists of two layers of 5-cm-thick concrete (1 cement: 1 1/2 sand: 2 aggregate) with mesh reinforcement and an asphalt seal between as added protection at building sites subject to flooding. The base may be easily modified to suit different ground conditions. The walls slope inward to a central entrance hatch at the top. This truncated cone shape gives a very rigid structure, both during and after construction, and it eliminates the need for a roof structure. The walls are reinforced with 2-m-long poles (water pipe or bamboo), reinforcing rods, and one layer of wire mesh on internal and external faces. The mortar is hand-mixed and is applied as a thick paste using trowels and fingers. No formwork is required to support the mortar. The wall mortar consists of 1 part of standard cement, 1.75 parts sand with the optional addition of a plasticizer to improve workability. Water/cement ratio is approximately 0.3; and with only enough water to hydrate the cement, no voids due to excess moisture are left in the ferrocement, which becomes impermeable.

The top may be cast on site or precast and erected before cementing the walls. It consists essentially of a ferrocement lid with

FIGURE 5: A completed ferrocement silo in Thailand.

circles of rubber to make airtight seals. An inner lid of aluminum (trashcan lid) with a polystyrene lining to insulate against heat and to prevent moisture condensation can also be used.

Controlling the water content of the mix and curing for several days under moistened sacking to avoid direct exposure to the drying effects of sunlight and wind are paramount construction considerations. On completion, the bin may be tested by filling it with water for one week. This is an excellent quality-control test because water is considerably heavier than products likely to be stored and any cracks or weak sections, caused by poor workmanship, can be readily seen as leaks.

Underground grain silos in Ethiopia. In Harar Province, Ethiopia, underground pits are the traditional method of grain storage. It is estimated that 62 percent of the farmers use pit storage exclusively. The

TABLE 1. Cost Record for First Experimental Silo, Thailand, 1969

Inputs	Quantity	Thai Cost (in U.S. $)
Labor		
Skilled	63 man-hours	$ 24
Unskilled	135 man-hours	20
	Total Labor Costs	$ 44
Materials		
Cement	1,000 kg	25
Sand	1,725 kg	3
Aggregate	965 kg	3.5
Mortar plasticizer[b]	2 kg	2
Sealant for the base[b]	5 kg	2
Paint	3/4 kg	7.5
Steel		
Chicken wire	2 rolls	18.5
No. 2 rod	80 m	2.5
Water pipe[b]	32 m	13
	Total Materials Costs	77
		TOTAL $121

[a]Labor figures refer to an initial experiment and can be drastically decreased in practice. Construction of several silos at the same time also reduces labor costs because time spent waiting for sections to cure can be used productively on adjacent bins.

[b]Used to date because of availability in Thailand but may not be necessary for adequate performance of completed silo.

SOURCE: R. B. L. Smith, et al., Thai Journal of Agricultural Science, July 1971, pp. 143-55.

basic shape of pit stores resembles that of a laboratory conical flask. The mouth of the pit is closed by strips of wood sealed with a mixture of mud and dung. The pits, if fairly well sealed and covered with a good depth of hard-packed soil, should provide a reasonably airtight storage chamber. In such a chamber any insects present in the stored grain should be killed as the oxygen is used up. However, unless the pit and grain are both dry, some mold growth is inevitable. In practice, few traditional pits are sufficiently airtight to eleminate insects, and mold damage is often considerable.

When the traditional pit is lined with ferrocement and provided with an improved airtight lid, a truly hermetic and waterproof storage chamber can be achieved. Most lined pits hold 1/2 - 2 tons. A 1/2 ton pit is correspondingly 1.75 meters by 2 meters. The ferrocement lining can be produced by any local laborers who are familiar with the use of cement in house building, but even local unskilled laborers can soon learn to do the work satisfactorily. After a 2-3 hour training period, unskilled laborers were able, without close supervision, to help other untrained workers with the techniques.

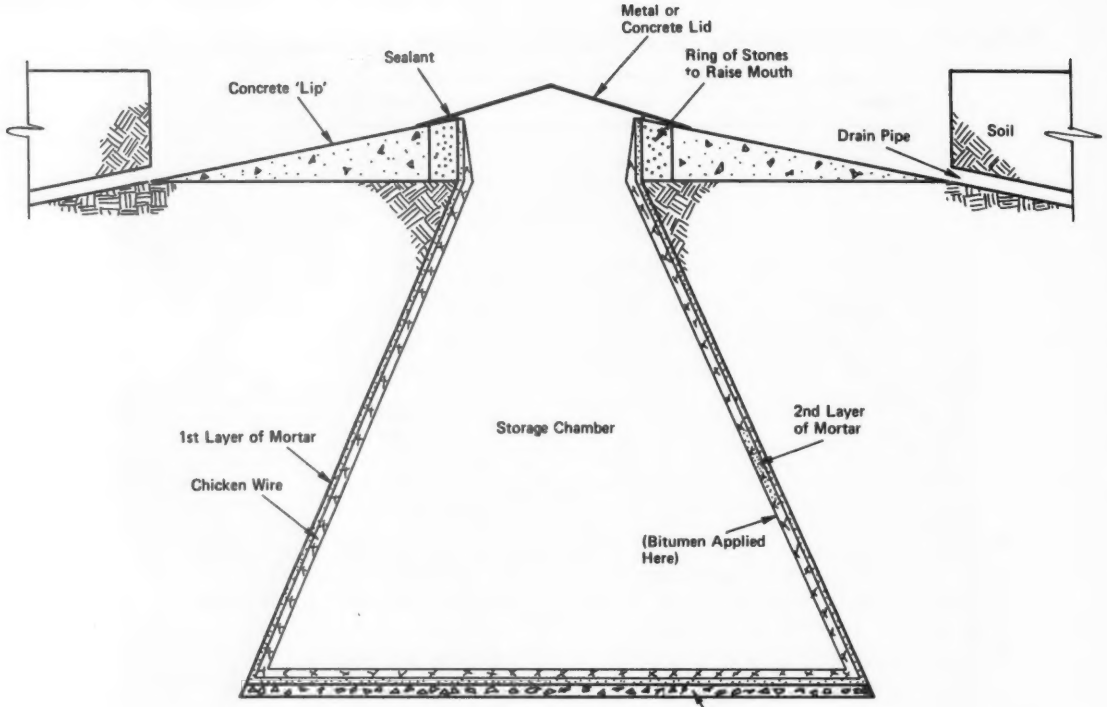

FIGURE 6: Cross-section of ferrocement underground storage pit.

TABLE 2. Costs of 1-Ton Ferrocment-Lined Storage Pit, 1972 (in U. S. $)[a]

Using a bitumen lining as waterproofing barrier	
Labor (skilled)	$ 3.50
Labor (unskilled farmer assisting skilled laborer)	nil
Materials	
Cement	5.20
Sand	nil
Aggregate	nil
Bitumen	1.00
Chicken wire	2.20
Miscellaneous — transport, hiring, tools, etc.	2.10
	$14.00
Using bitumen emulsion ("Flintkote") - optional; extra cost	6.50
	$20.50

[a]Based on average for all of Harar Province, Ethiopia. In remote areas, the price of materials is likely to be higher; in areas close to large towns, considerably lower.

Low-Cost Roofing

Rapid population growth and industrial development have created overwhelming demands on human settlements. Of the needed new housing materials and construction methods, the most critical component is approriate roofing. For most people a long-lasting roof is too expensive. Yet, most roofs manufactured from cheaper local materials such as grass or reeds (thatch) or earch products (sand, mud, rock) are short-lived and dangerous in an earthquake, flood, or fire. Thatch is notorious for harboring vermin and insects. Furthermore, an adequate roof covering is often impractical because it needs a high-cost supporting structure. For instance, tiles make excellent roofs, but they are so heavy they require extensive supporting frames. In many regions, wooden supports decay rapidly, though the covering remains sound.

Ferrocement appears to have decided advantages over several other roofing materials, and it might play a major role in housing construction in developing countries although little work has so far been done to determine its feasibility, costs, and acceptability. Ferrocement roofing materials can be factory mass-produced in prefabricated form, a process best suited to the concentrated demand of urban areas. Ferrocement could also be fabricated on site in rural areas, using local labor and materials. Freer in concept and makeup than most conventional roofing, ferrocement can be shaped into domes, vaults, extruded shapes, flat surfaces, or free-form areas. Before ferrocement can be used widely for roofing, however, experiments will be required to determine the shapes and types of roofing members to be manufactured, and to explore designs and methods for anchoring and bolting these various shapes to supporting walls. On-the-job training centers may be required to introduce the new material and its new building techniques.

[Extracted from Ferrocement Applications in Developing Countries, Board on Sciences and Technology for International Development, National Academy of Sciences, Washington, D. C., 1973. Chapters 2, 4 and 6; Appendices 2 and 3.]

A New Technique for Waterproofing Mudwall

M. Aslam and R. C. Satiya

[In many countries, as in much of India, village houses are built of relatively soft earth blocks (i. e. mudwall) which will crumble under heavy rains. An inexpensive method of strengthening and waterproofing them with asphalt mixed with kerosene is described.]

A vast majority of the Indian population lives in villages where most of the houses are built of mud. The rains cause erosion of the walls of the houses and they often need major repairs every few years. Waterproofing mudwalls could be undertaken either in the construction of new houses or for the protection of existing houses. The known methods for the protection of mudwalls against rains are limited to in-situ soil stabilization by the addition of asphalt, cement, etc. or application of non-erodable mud plaster using asphalt cut-back. Due to the difficulty of uniform mixing of asphalt with the soil, both these methods are cumbersome and expensive. Moreover these methods are only suited to new constructions.

The New Approach

The Central Building Research Institute, Roorkee, India, has worked out a speedy, cheap and effective method of waterproofing existing mudwalls. It consists of spraying a suitable material which gets absorbed in the wall and makes it waterproof. The absorbed material should be water-repellent and durable against weathering.

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The waterproofing solution is prepared from asphalt and kerosene oil. The material can be easily prepared by the villagers themselves as no special technique or equipment is required in its preparation. A drum containing normal asphalt used for road work (80/100 grade) is heated until it melts. Gradually 25 kg of molten asphalt are added to fifty liters of kerosene oil. When all the 25 kg of the asphalt have been dissolved, the solution is allowed to cool, and transferred to a barrel through a fine sieve in order to exclude any undissolved asphalt or foreign matter which would otherwise choke the pump during operation. Care should be taken that the asphalt is not overheated. This material, unlike asphalt emulsion, is very stable and can be stored for long periods without damage. The material should, however, be stored in a closed container and kept in a cool place away from fire. Any manual spray pump can be used for this purpose, including those now used in rural areas for spraying insecticides and pesticides.

The mudwall to be waterproofed should be plain and free from cracks. It is advisable to repair any cuts or holes and apply a coat of mud-gober slurry on the wall to seal off all the cracks on the surface before spraying. This coating also gives a porous and strong substrate for good absorption of the waterproofing material. The wall should be allowed to dry fully before spraying. The spraying should not be done on whitewashed mudwall or on a wall whose surface has been rendered dense and impervious by repeated application of claywash.

Application

After testing the equipment the material is sprayed twice or thrice depending upon the porosity of the surface at an interval of at least four hours on a clear sunny day, thus allowing time for the previous coat to be absorbed fully. The sprayer with a vertically spread jet should move horizontally on the wall starting from the top. Any choking in the pump should be cleared immediately and spraying resumed only when the jet is normal. Spraying on a wall directly facing the sun should be avoided, otherwise the material will not be properly absorbed in the wall due to high evaporation rate of the solvent in the sun. Care should be taken to see that the material is also not oversprayed, otherwise it will leave an oily black surface on the wall; this excess asphalt may flow in hot weather. The spraying pump should be washed immediately after use by pumping kerosene oil through it. The washings should be collected and used for preparing the next batch of the material. Two persons can spray about 200 square meters of mudwall in one day. This includes time for the preparation of the material.

The mudwall after being treated with this material appears dark

grey in color. To most of the residents this color may not be acceptable. In such cases the treated wall can be whitewashed by adding animal glue in limewash. This whitewash adheres well to the sprayed surface and gives a normal whitewashed appearance to the house.

This treatment was given on the external walls of eight mud-wall (kuccha) houses in nearby villages. These walls have withstood successfully a number of heavy downpours in the current rainy season. Each square meter of the wall surface consumed up to 1 kg of the waterproofing material. The total cost including cost of labour comes to about Rp. 1.30 ($0. 17) per square meter. The cost of limewash including cost of animal glue is about Rp. 0. 20 ($0. 03) per square meter. According to normal practice in villages, the white-washing is done by the residents themselves. The labor cost of white-washing has, therefore, not been taken into account. The total cost of waterproofing and whitewashing is, therefore, about Rp. 1.50 ($0. 20) per square meter.

[Extracted from "A New Technique of Waterproofing Mudwall," Masalah Bangunan, Vol. 20, No. 2, July 1975, pp. 12-13. Regional Housing Center of the Ministry of Public Works and Electric Power, Bandung, Indonesia.]

Editorial Note: Experiments in stabilizing earth walls (adobe) with asphalt have also been carried out in Peru, with AID support, and have now reached a point of adoption by Peruvians. Some of this work was spurred by the need to rebuild villages after the big Peruvian earthquake several years ago; following the recent earthquake in Guatemala, the Peruvians have begun to share their experience with Guatemalans.

Sulphur Bonding of Concrete Blocks

Allen C. Ludwig

[Sulphur is a material available at low cost in a number of developing countries that appears to have uses in construction not previously explored. This article describes recent results of its use for bonding concrete blocks in Colombia. Other uses may include the sealing of concrete water pipes and their joints, as well as the water-proofing and/ or strengthening of other types of material; for example, baskets treated with sulphur can be made waterproof.]

The surface bond technique for wall construction consists of stacking concrete blocks or other building modules into a wall without mortar being placed between the blocks. A sulphur-based bonding material is then applied to both surfaces of the wall to form a structural membrane against the blocks which waterproofs the wall and binds it into an integral unit. In 1963 a small building was built using a sulphur base coating at Southwest Research Institute in Texas. Today this building is still in excellent condition and continued service is anticipated for many years to come. In 1969, under a United Nations project, several walls were constructed in Guatemala employing concrete block as well as fired clay tile, and these walls are still intact. To our knowledge these are the two oldest sites employing structures with the surface bonding technique and both used the sulphur coating. More recently other structures have been built employing the surface bond technique in Bogotá and Cartagena, Colombia, and in the United States.

Construction Using Sulphur Base Coatings

For construction with sulphur base coatings, the coating is applied hot in the molten stage. As seen in Figure 1, a first layer of concrete blocks is bonded to a slab by pouring the sulphur into the cavity of the block, which

Mr. Ludwig is at the Southwest Research Institute in San Antonio, Texas.

establishes a firm foundation for the wall. Next, blocks are stacked to a convenient height without any mortar between them, and the sulphur formulation is then painted onto the surface. Conventional paint brushes may be used; however, it was found that small brooms worked as well as the paint brushes and were considerably less costly.

Figure 1: Bonding the first row of blocks with sulphur.

The coating is applied to a thickness of 2 to 4 mm. At this thickness, the coating will solidify in 20-30 seconds. The entire wall surface can be coated with the sulphur formulation, or only the joints can be painted as in Figures 2 and 3. The preferred method is to coat the entire wall surface since this gives a stronger and more waterproofed surface. However, painting only the joints requires less than half as much sulphur coating, thus being more economically attractive. If the wall is to be plastered eventually with conventional cement plaster, then painting only the joints allows for a considerable savings in cost and material.

With the sulphur base system, lintels (horizontal beams for the top of a window or door) can be prepared very quickly and easily on the job site. Concrete blocks are butted end to end, without mortar between the joints. The sulphur coating is applied, preferably to the entire surface, but the joints only can be coated if desired. Within 5 to 10 minutes the blocks are firmly jointed, and the lintel can be placed atop window or door openings as in Figure 4 and then coated in the same manner as blocks being added to the wall. The maximum span that can be bridged in this manner is determined principally by the flexural strength of the concrete block itself, and should be determined on site using the blocks available. Two methods were used for improving the strength of the blocks. The first method was

Figure 2: Painting only the joints with the sulphur coating.

Figure 3: Painting the sulphur coating by brush.

Figure 4: Setting a pre-made lintel in place.

to fill the cavity of the blocks with the sulphur coating formulation (the formulation left over at the end of the day was used for this application). A second means of improving the strength of the concrete blocks was to submerge the blocks in molten sulphur, or the sulphur plasticized with dicyclopentadiene. The length of time required to saturate the block with the sulphur will depend on how wet the concrete block is: with the relatively dry blocks that were used in Colombia, this took from 30 minutes to 1 hour.

Sulphur Coating Formulations and Equipment

The sulphur coating formulations consist of sulphur, a plasticizer, and a reinforcing fiber. The preferred plasticizer for the sulphur coating is dicyclopentadiene. In addition to plasticizing the sulphur, the dicyclopentadiene imparts a fire retarding characteristic to the formulation. In all of our work to date dicyclopentadiene has been the most practical modifier, and is also the most economical. By far the most widely used fiber has been glass fiber; however, other fibers have been used including asbestos.

The optimum formulation developed as a coating in the U. S., designed specifically for spraying,had the following formulation in parts by weight:

100	sulphur
7. 5	talc
3	milled glass fibers
3	dicyclopentadiene

The talc suspends the glass fibers and imparts a thixotropic nature to the formulation to prevent its flow on a vertical wall. The milled glass fibers are in an almost powder-like form which allows for a sprayable formulation. The sulphur formulation employed in the houses in Colombia was as follows:

100	sulphur
5	asbestos
3	dicyclopentadiene

The asbestos may be cheaper and more easily available; the flexural strength is less, but is adequate for most purposes.

For melting the sulphur, any available heat source may be used including wood, coal, or gas. Bottled propane gas is highly desirable because of the control by regulating the flame. The quantity used varied from 35 to 50 kilos per house depending on the size of the house. Any convenient sized metal container may be used for melting the sulphur; in Colombia, two 55 gallon drums were used. To help insulate and hold the heat, concrete blocks were stacked around the tanks. Approximately 250 kilos of sulphur were melted in each tank at one time.

For speeding the melting of the sulphur one technique is to place only 20-25 kilos of solid sulphur in the drum. As soon as all of this is melted,

additional solid sulphur is added, making sure that the sulphur stays liquid. If all of the sulphur is added initially, it will take much longer to melt the sulphur because solid sulphur is a very poor heat conductor. By melting in the manner described, the 250 kilos were usually melted and the temperature raised to 145°C within 1 1/2 to 2 hours. Once the sulphur temperature is at 145°C, the dicyclopentadiene is added and allowed to react for 15-20 minutes before the asbestos is finally added. Caution should be taken that the temperature does not exceed 150°C, or the quantity of dicyclopentadiene does not exceed 3 parts per 100 parts of sulphur, or else the dicyclopentadiene can overreact with the sulphur to form a very viscuous, rubber-like material that must be discarded. The asbestos usually contains water, so that there will be bubbling and foaming when it is first added to the molten mix. Once the foaming has stopped and the temperature of the mix is 145-150°C, the material is ready to be applied.

The recommended safety equipment for personnel applying the sulphur mixture is long sleeves to prevent burns if sulphur is splattered on the arms, gloves, to protect the hands, and goggles or glasses to protect the eyes. It should always be remembered that molten sulphur is at a temperature above that of boiling water, but at 150°C is usually well below that of asphalts as currently used for roofs and roadway repairs.

Construction of houses. Two single storey houses were constructed in Bogotá, and two in Cartagena. The walls were 10 blocks high plus the mortar joints. Using a crew of two masons and two helpers, it took 2 1/2 days to construct the walls on each house, which is comparable to what is required on the conventional houses. With practice, the crews would become more proficient and could possibly construct them in less time. One problem encountered in the construction involved irregularly shaped blocks or large cracks in some joints which required excess material and considerable time to fill. It was found that by stuffing paper or other filler material in the large cracks first, and then painting over this with the sulphur, this problem was eliminated.

In order to speed construction using the sulphur system, spraying the coating would be very desirable; a small pump was purchased locally in Bogotá (see Figure 5). The use of such a pump would allow for either spraying a coating over the entire block surface or controlling the width of the stream for coating only the joints.

From the results thus far obtained in Colombia, the surface bond technique appears at least competitive in cost with conventional mortar construction and, depending on specific house designs, could offer considerable savings in material costs, as was found in Cartagena. Savings in time and materials were made possible by use of sulphur-bonded blocks for lintels in place of the customary steel reinforced beams.

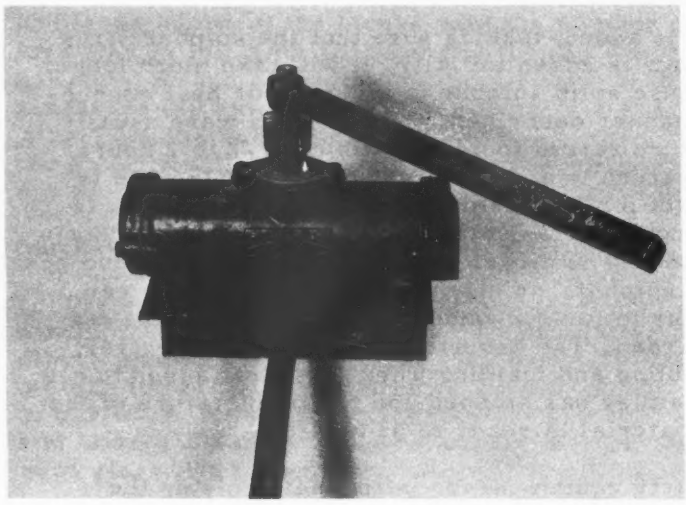

Figure 5: Small pump used to spray sulphur in laboratory tests.

The labor force seemed quite capable of adapting this technique to meet local needs. One possible disadvantage of using sulphur is that it is flammable, unlike conventional mortar. However, if subjected to high heat the sulphur burns slowly, and does not weaken a sulphur-bonded structure. In low cost housing, a sulphur-bonded concrete structure is far less hazardous than one using wood, thatch, or other vegetable materials, and the smell of burning sulphur will alert householders to a fire long before the damage to property or persons can occur.

[Extracted from "Technical Aspects of Surface Bonding," Techniques for Sulphur Surface Bonding for Low Cost Housing, an unpublished report prepared by the Southwest Research Institute, San Antonio, Texas, for the U. S. Agency for International Development, 1975.]

Editorial Comment: Some negative aspects of the sulphur-bonding method that have been noted by technical experts include: 1) There have been no successes so far in the efforts to use sulphur for protection and strengthening of low cost blocks of earth (adobe), which would be more suitable than concrete for lowest cost housing. 2) With concrete blocks, sulphur bonding makes possible a stronger structure than conventional mortar; but this is most useful for tall multi-storey buildings,rather than single-storey houses where it has no proven cost advantages except for lintels. 3) Burning sulphur may be medically hazardous; and the smell of sulphur makes it unattractive to work with. In conclusion, the uses of sulphur merit further exploration in several directions, but the research so far has not clearly identified areas of superiority for lowest cost housing.

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